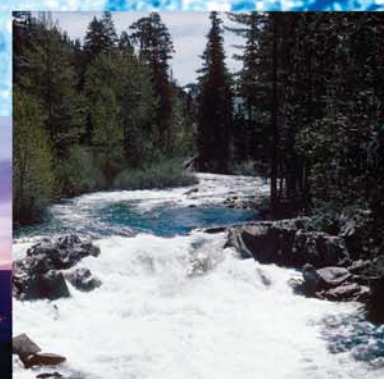

Resource Management Strategies
Volume 2

California WaterPlan Update 2005

A FRAMEWORK FOR ACTION

Department of Water Resources Bulletin 160-05 December 2005

The California Water Plan Update 2005
is organized in five volumes:

Volume 1:	Strategic Plan
Volume 2:	25 Resource Management Strategies
Volume 3:	12 Regional Reports
Volume 4:	Reference Guide (60+ articles)
Volume 5:	Technical Guide (Online documentation)

The final California Water Plan Update 2005 and the Water Plan Highlights briefing book were completed in December 2005. The five volumes of the update, the Highlights document, and the introductory video, "Water for Tomorrow," are contained on the CD and DVD below and also available online at www.waterplan.water.ca.gov.

Printed copies are available. The Highlights briefing book, which contains the CD and DVD, is available at no charge. Volume 1, 2, and 3 are $15 each. Volume 4 is $50. For printed copies, contact:

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State of California
The Resources Agency
Department of Water Resources

California Water Plan Update 2005

A Framework for Action

Bulletin 160-05
December 2005

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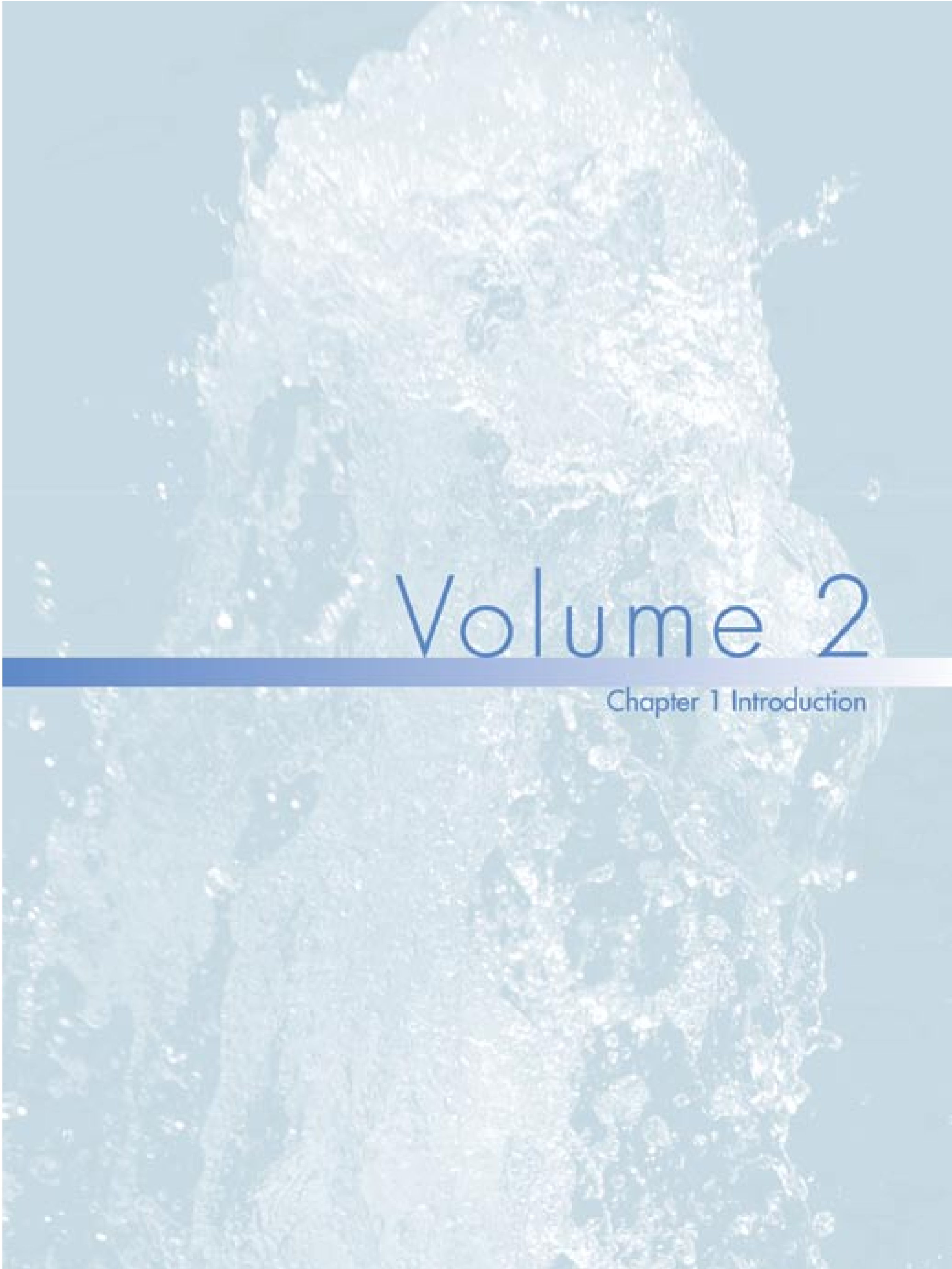
Volume 2 - Resource Management Strategies



Volume 2

Chapter 1 Introduction

By making the right choices, regions diversify their water portfolios, make the right investments, and meet their water demands in 2030. Each region chooses an appropriate mix of resource management strategies based on its own water management objectives and goals. (DWR photos)

Chapter 1 *Introduction*

A resource management strategy is a project, program or policy that helps local agencies and governments manage their water and related resources. For example, urban water use efficiency is a strategy to reduce urban water use. A pricing policy or incentive for customers to reduce water use also is a strategy. New water storage to improve water supply, reliability and quality is another strategy.

Think of these strategies as tools in a tool kit. Just as the mix of tools in the kit will depend on the job, the combination of strategies will vary from region to region depending on climate, projected growth, existing water system, and environmental and social conditions. At the local level, it is important that the proposed strategies complement the operation of the existing water system. Some strategies may have little value in some regions. For example, because of geology, the opportunity for groundwater development in the Sierra Nevada is not nearly as significant as in the Sacramento Valley. Other strategies may have little value at certain times. For example, precipitation enhancement may not be effective during droughts.

A key objective of the California Water Plan is to present a diverse set of resource management strategies to meet the water related resource management needs of each region and statewide. Chapter 2 of Volume 1 describes the importance of regional planning and presents general considerations for preparing sustainable integrated resource plans suitable for each region's unique character. Volume 2 describes 25 resource management strategies (listed alphabetically in Box 1-1 and in the articles following the introduction) that can be combined in various ways to meet the water management objectives and goals of different regions and to achieve multiple benefits.

Resource managers need to examine all of these strategies to identify the best mix for their region. The more a region can diversify its portfolio, the more robust and resilient it will be in facing future unknowns.

Planning a Diversified Portfolio

As California changes, local agencies and governments continue to use different methods of managing water. Growing population, changing regulations, and evolving public attitudes and values are a few conditions that have influenced recent decisions about water.

Strategies are the tools that local agencies and governments should consider when they plan. The basic intent is to prepare good plans that are diversified, satisfy regional and state needs, meet multiple objectives, include public input, address environmental justice, mitigate impacts, protect public trust assets, and are affordable. Additional recommendations for planning and implementation can be found in Chapter 5 of Volume 1.

While the strategies are based on the best available information, Department of Water Resources (DWR) has not conducted detailed studies to verify this information on a statewide basis because the performance of individual strategies will depend on how they are combined and used in each region. DWR, with the help of an Advisory Committee, is developing a plan for more comprehensive data and analytical tools for use in the next Water Plan Update.

Additional analyses (described in Chapter 4 of Volume 1) will provide policymakers and resource managers more quantitative information on the performance of various strategies, interactions between strategies, tradeoffs, and potential groupings of strategies. DWR will consider several different future scenarios in future Water Plan Updates that can be used by planners to test the performance of alternative strategy mixes (see Chapter 4 of Volume 1).

Organization of Resource Management Strategy Chapters

While the chapters were written by different experts, the narratives for each strategy are organized similarly. Each includes:

- A short definition and background material on the strategy.
- A section on the current use of the strategy in California provides an overview of what is happening today.
- A section on benefits includes a discussion on how much water, demand reduction, ecosystem restoration, or other benefits could be achieved statewide by 2030. Since the application of these strategies can vary widely among regions, the strategy descriptions are from a broader, statewide perspective. More detailed information on some of the strategies is also presented in the Reference Guide (Volume 4).
- Estimates on implementation costs when available. In most cases, costs are highly dependent on where they are done and can only be estimated in broad ranges in these brief narratives.
- The tradeoffs and challenges associated with implementing each strategy. Each strategy narrative includes a summary of major issues facing the strategy. For instance, with ocean water desalination there are issues with water intakes and brine disposal.
- Recommendations on how the strategy could be implemented over the next 25-30 years to minimize its impacts, as well as how to promote additional implementation. Many of the recommendations are for the State to enact technical support to help regional groups make better decisions in the use of the strategies. The narratives do not include specific recommendations for funding of individual strategies since local and regional efforts will need to complete additional analysis before making decisions to proceed with strategies. General recommendations that would apply to all strategies are presented in Chapter 5 of Volume 1 rather than in the individual strategy narratives. Common recommendations include the need for monetary investment and consideration of public trust, environmental justice, and environmental impacts.

While the resource management strategies are presented individually, they can complement each other or there may be trade-offs between strategies to be considered. For instance, water from a recycling project could contribute to ecosystem restoration and groundwater recharge, while water use efficiency might reduce the opportunity for recycling and reuse.

In addition, the strategy narratives recognize the relationship of water and other resources. However, DWR does not have authority over some of these resources. As appropriate, these policies and programs are articulated in the various resource management strategy narratives.

Box 1-1 Resource Management Strategies

Agricultural lands stewardship
Agricultural water use efficiency
Conjunctive management and groundwater storage
Conveyance
Desalination
Drinking water treatment and distribution
Economic incentives (Loans, Grants, and Water Pricing)
Ecosystem restoration
Floodplain management
Groundwater remediation/Aquifer remediation
Matching water quality to water use
Pollution prevention
Precipitation enhancement
Recharge areas protection
Recycled municipal water
Surface storage-CALFED
Surface storage-regional/local
System reoperation
Urban land use management
Urban runoff management
Urban water use efficiency
Water-dependent recreation
Watershed management
Water transfers

Other resource management strategies (includes crop idling for water transfers, dewvaporation, fog collection, irrigated land retirement, rainfed agriculture and water bag transport/storage technology)

Strategy Summary Table

The Strategy Summary Table is a one-page overview of the 25 resource management strategy articles. The data and information presented in Table 1-1 and the Volume 2 strategy narratives were developed by DWR in consultation with other experts and stakeholders. The actions in the table are grouped by resource management strategies (top section) and essential support activities (bottom section), such as planning and research and development. The table presents the resource management strategies in subgroups, which include demand reduction, operational efficiency and transfers of water, water supply, water quality, and resource stewardship. Table columns include:

- **Left column –** shows the *Resource Management Strategies* (top section) and *Essential Support Activities* (bottom section) that are available to regions to achieve various water management objectives.
- **Center columns –** show *Water Management Objectives* that could be achieved by implementing a particular strategy. The table shows dots (•) where the resource management strategy articles indicate that the strategies could have direct and significant benefits for various water management objectives. Note that most resource management strategies can help achieve multiple water management objectives.
- **Right column –** shows a range of *Cumulative Costs for each Option by 2030* of implementing a strategy or performing a support activity to achieve the indicated benefits by 2030 (not including ongoing operation and maintenance costs). Note that the costs in the table are displayed as the cumulative sum (over about 25 years in 2005 dollars) of expected costs by year 2030. Backup for each cost estimate are contained in the strategy narratives. Details on implementation and financing are presented in Chapter 5 of Volume 1.

The dot placement can be viewed either horizontally for a given resource management strategy or vertically for a given water management objective. As shown (vertically) in the table, most of the resource management strategies can provide water supply benefits. Likewise, many strategies can contribute to improved water quality, environmental benefits and other water management objectives.

While most of the resource management strategies have the potential to contribute to multiple water management objectives, any individual site-specific project or program within a resource management strategy may contribute to only one, or a few of the objectives. For example, it is unlikely that the agricultural land stewardship practices on a single farm will contribute to all the water management objectives (as indicated in Table 1-1). In aggregate, however, the combined agricultural land stewardship practices on many farms can contribute to all the water management objectives as shown in the table.

As part of the strategy narratives, DWR prepared preliminary estimates of water supply benefits which can include water supply increases and water demand reductions. Those estimates are shown as ranges in Figure 1-1 for some of the management strategies. The figure shows that there is considerable capacity to provide water supply benefits between the eight strategies included in the figure. In some cases, the values represent a local or regional benefit and may not provide statewide benefits. In addition, implementing some strategies, like water dependent recreation or ecosystem restoration may increase total water demands. Many strategies were not included in the figure because their potentials for additional water supply are either incidental (small), or have not yet been estimated. Supply benefits will be better quantified during the subsequent water plan update. Some strategies do not produce water supply benefits.

The information and data in Table 1-1, Figure 1-1 and the Volume 2 strategy narratives should be treated as preliminary indicators of the scale and type of potential benefits and associated costs. In most cases, assumptions and methodologies are unique to given strategies and neither benefits nor costs are additive among different strategies. The costs, benefits, and negative impacts of actually implementing these strategies in real-world locations could vary significantly depending upon local factors and project-level complexities. Project-level considerations include the extent of the management strategies already incorporated into the existing system, proposed location of new strategies, operations, mitigation, system integration, presence of cultural or environmental resources. Therefore, local and regional water management efforts should develop their own estimates of costs, potential benefits, as well as other tradeoffs associated with application of any particular strategy.

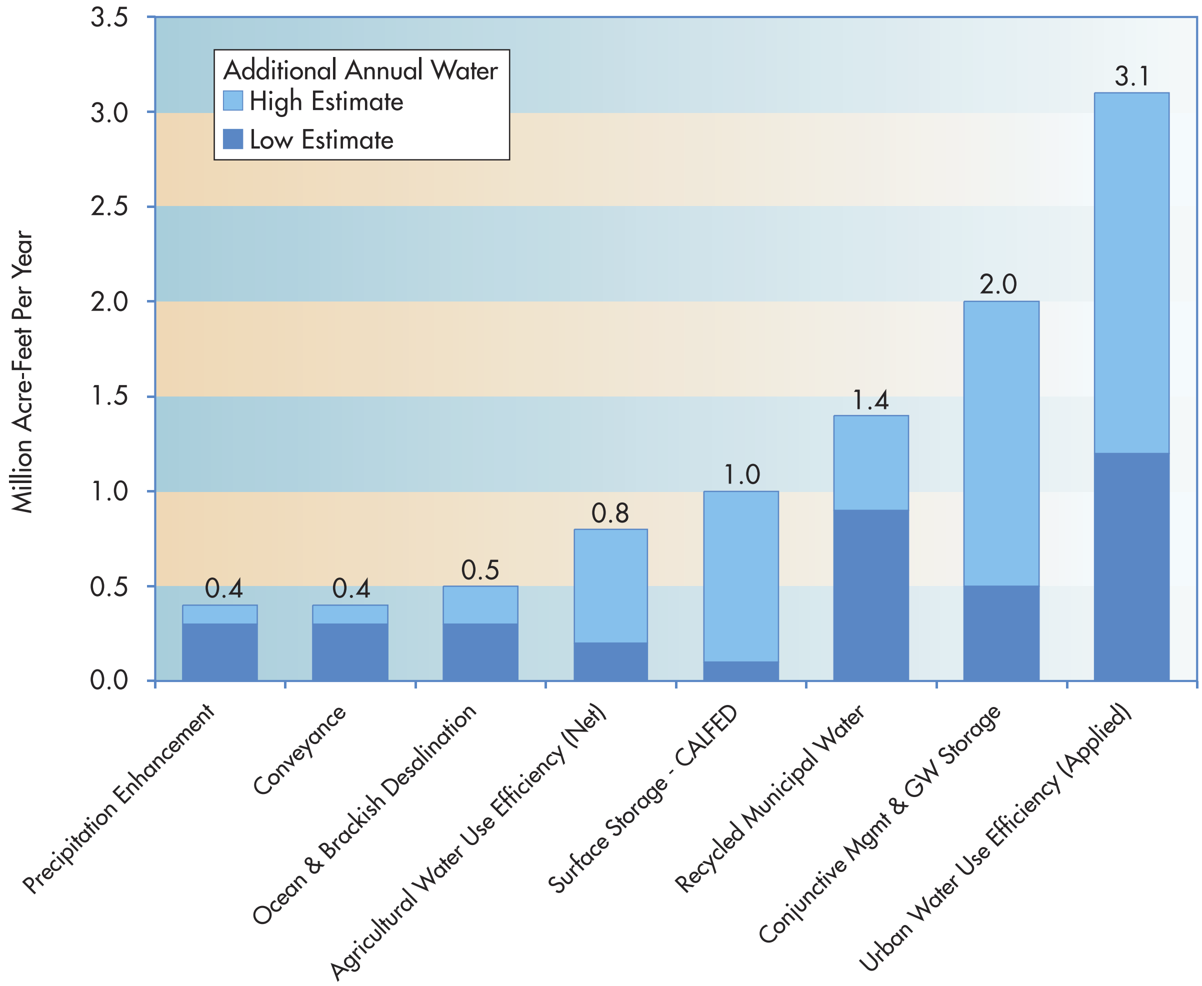
The table can help guide selective reading of the following 25 chapters.

Table 1-1 Strategy summary table

Resource Management Strategies	Water Management Objectives									Cumulative Cost of Option by 2030 ($ Billion) See narratives for backup
	Provide Water Supply Benefit	Improve Drought Preparedness	Improve Water Quality	Operational Flex & Efficient	Reduce Flood Impacts	Environmental Benefits	Energy Benefits	Recreational Opportunities	Reduce GW Overdraft	
Reduce Water Demand										
Agricultural Water Use Efficiency	•	•	•	•		•	•		•	0.3 - 4.0
Urban Water Use Efficiency	•	•	•	•		•	•			2.5 - 6.0
Improve Operational Efficiency & Transfers										
Conveyance	•	•	•	•	•	•	•	•	•	0.2 - 2.4
System Reoperation	•	•	•	•	•	•		•		
Water Transfers		•	•	•		•				
Increase Water Supply										
Conjunctive Management & Groundwater Storage	•	•	•	•	•	•			•	1.5 - 5.0
Desalination - Brackish	•	•	•	•					•	0.2 - 1.6
-- Seawater	•	•	•	•					•	0.7 - 1.3
Precipitation Enhancement	•	•					•			0.2
Recycled Municipal Water	•	•	•	•		•	•	•	•	6.0 - 9.0
Surface Storage - CALFED	•	•	•	•	•	•	•	•	•	0.2 - 5.6
Surface Storage - Regional/Local	•	•	•	•	•	•		•	•	
Improve Water Quality										
Drinking Water Treatment and Distribution			•							17.0 - 21.0
Groundwater/Aquifer Remediation	•	•	•						•	20.0
Matching Quality to Use	•	•	•							0.1
Pollution Prevention			•			•		•		15.0
Urban Runoff Management	•	•	•		•	•		•	•	
Practice Resource Stewardship										
Agricultural Lands Stewardship	•	•	•	•	•	•	•	•	•	5.3
Economic Incentives (Loans, Grants, and Water Pricing)	•	•	•	•		•			•	
Ecosystem Restoration	•			•	•	•		•		7.5 - 11.3
Floodplain Management				•	•	•		•		0.5
Recharge Areas Protection	•	•	•		•				•	
Urban Land Use Management	•		•		•	•		•	•	
Water-Dependent Recreation								•		3 - 6% of total
Watershed Management	•	•	•		•	•			•	0.5 - 3.6
Other Resource Management Strategies	Objectives vary by strategy (see narratives in remainder of Volume 2)									
Essential Support Activities to Integrate Strategies and Reduce Uncertainty										
The following support activities are essential for successfully integrating packages of these resource management strategies. Compared with the costs of implementing the resource management strategies, the costs are relatively small for the essential support activities shown below (see Chapters 2 and 4 of Volume 1).										
Regional Integrated Resource Planning & Management										0.25
Statewide Water Planning										0.17
Data & Tool Improvement										0.25
Research & Development										0.25
Science										3 - 5% of total

The resource management strategy estimates are not additive. Although presented individually, they are in most cases alternatives that will either complement each other or compete for limited system capacity, funding, water supplies or other component necessary for implementation.

Figure 1-1 Range of additional annual water for eight resource management choices



This graph shows the potential range of more water demand reduction and supply augmentation each year for eight resource management strategies. Low estimates are shown in the lower (dark blue) section of each bar. The water supply benefits of the resource management strategies are not additive. As presented here, urban water use efficiency includes reduction in both consumptive and non-consumptive uses (or applied water), whereas agricultural water use efficiency only includes reduction in consumptive uses (or net water).

Volume 2

Chapter 2 Agricultural Lands Stewardship

Through agricultural lands stewardship, farm and ranch landowners produce public environmental benefits in conjunction with the food and fiber they have historically provided while keeping land in private ownership. (DWR photo)

Chapter 2 *Agricultural Lands Stewardship*

Agricultural lands stewardship broadly means conserving natural resources and protecting the environment by land managers whose stewardship practices conserve and improve land for food, fiber, watershed functions, soil, air, energy, plant and animal and other conservation purposes. Agricultural lands stewardship also protects open space and the traditional characteristics of rural communities. Moreover, it helps landowners maintain their farms and ranches rather than being forced to sell their land because of pressure from urban development. For this paper, "agricultural lands stewardship" means farm and ranch landowners – the stewards of the state's agricultural lands – producing public environmental benefits in conjunction with the food and fiber they have historically provided while keeping land in private ownership. This paper describes methods used to encourage implementation of stewardship practices.

This strategy is focused on agricultural land (cropped and grazed land) as defined by the California Land Conservation (Williamson) Act administered by the California Department of Conservation Division of Land Resource Protection. Other resource-based land uses, such as forestry and mining, are addressed by the Watershed Management strategy in Chapter 25, Volume 2. Agricultural land stewardship can take place on a particular parcel of land, on multiple parcels in one landowner's possession, or in an integrated manner on agricultural lands regionally or statewide. The goal of this approach is to promote sustainable agricultural practices with an economic return, while managing these productive lands for multiple benefits, including water management improvements. Box 2-1 shows examples of agricultural lands stewardship practices.

There are many ways that agricultural lands can be profitably managed. Crop lands can be managed to reduce or avoid stream bank erosion or stormwater runoff. Stream bank stabilization may include a buffer strip of riparian vegetation which slows bank erosion and filters drainage water from the fields. These measures can minimize or reduce the effects of agricultural practices on the environment and help meet governmental regulatory requirements while also reducing long-term maintenance problems for the landowner.

Stream bank protection is often needed when stream configuration is modified. Use of willow mattresses helps protect these reshaped stream banks. The willows grow into a stable plant community that provides food, habitat, and overhanging shade which helps maintain cool stream water temperature for fish. Other fish friendly techniques, such as the use of logs and overhangs are also incorporated into stream bank protection to provide shade for fish. Some portions of the property may be left untouched to allow for natural flooding. Removing non-native plants, such as mugwort, vinca and other exotics, enables native plants to become established. Combining these measures along stream banks avoids the need to use environmentally damaging riprap.

Other agronomic practices include planting cover crops to encourage beneficial insects and reducing or eliminating the need for pesticides, using recycled compost and other sources for fertilizer, and reusing waste water for irrigation. Farm ponds contribute to flood management and groundwater recharge as well as nesting and feeding habitat for various species of waterfowl and terrestrial animals. Farm ponds also can be used to help correct field drainage problems and capture wastewater. Agricultural pond management for water quality also may be a source of water for wildlife with appropriate water quality management. Wetlands can be created on farmland by incorporating rice straw into the soil after harvest.

Fencing can be installed to keep cattle out of creeks. Installing fish screens on ditches prevents entrapment of fish. Water diversions can be designed to operate without creating obstacles to migrating fish.

Crop idling is an agronomic practice to benefit the soil or for other management purposes. Crop idling may be used in conjunction with drought management programs. Drought payments to farmers could be used on farm-related investments, purchases and debt repayment, or may be spent or invested outside the community. Crop idling that is strictly for the purpose of water transfers is discussed in Chapter 26 in Volume 2, Other Resource Management Strategies.

Integrated on-farm drainage management (IFDM) can be used to protect and enhance farmland, wildlife and water resources in drainage problem areas. The goal of IFDM is to eliminate the need for discharging subsurface drainage water from farms into waterways or evaporation ponds. The IFDM system manages irrigation water on salt-sensitive high-value crops and reuses subsurface drainage and tailwater on increasingly salt-tolerant crops. Biological filters, drainage and tail water systems, crop management and salt harvesting in an evaporation system improve water use efficiency, provide for the use of concentrated drainage water, and eliminate the need to dispose of agricultural drainage water. This approach to the management of agricultural lands affected by saline water and perched water tables has primarily been used on the west side of the San Joaquin Valley. It offers a temporary alternative to retirement of agricultural lands.

Agricultural Lands Stewardship Initiatives

Agricultural lands stewardship is not a new concept. Under various names, it has been practiced and encouraged by the California Department of Conservation's programs, and the U.S. Department of Agriculture (USDA) through the Natural Resource Conservation Service and various nongovernmental entities for many years. The California Resource Conservation Districts (RCDs), and other entities, specialize in working with private landowners in watershed management and coordination strategies. Governmental land acquisition programs are not agricultural stewardship because they take farm lands out of production. These programs are limited because they

Box 2-1 Examples of Agricultural Lands Stewardship Practices

- **Wetland Restoration –** Wetland acreage improves water quality by filtering out pollution and sediments. It also helps flood management by slowing the flow of water. Healthy wetlands are indispensable for recharging underground aquifers and providing specific wildlife habitat.
- **Shallow-Water Wildlife Areas –** Shallow water areas provide habitat and water for wildlife. Temporary rice field habitat also provides resting and feeding grounds for waterfowl and shorebirds and related terrestrial species. Rice field flooding speeds the decomposition of rice straw, reduces air pollution, improves soil fertility and helps with the decomposition of agricultural chemicals.
- **Windbreaks –** Rows of trees or shrubs along field boundaries help control soil erosion, conserve soil moisture, improve crop protection, provide livestock shelter and wildlife habitat, reduce drainage water, and increase carbon sequestration (removal of carbon dioxide from the atmosphere).
- **Irrigation Tailwater Recovery –** Collection, storage and transportation facilities help capture and reuse irrigation runoff water to benefit water conservation and off-site water quality. [See Chapter 3 in Volume 2, the Agricultural Water Use Efficiency strategy]
- **Filter Strips, Grassed Waterways, Contour Buffer Strips –** These are practices to reduce erosion and provide water quality protection, with some wildlife benefits depending on management.
- **Conservation Tillage –** Tillage of soils increases water infiltration and soil water conservation, reduces erosion and water runoff, sequesters carbon, and improves soil ecosystem and habitat quality.
- **Noxious Weed Control –** This practice establishes self-sustaining populations of "control organisms" to control or prevent weed infestations. Mowing, discing, plowing, and grazing are some of the practices that can be used for noxious weed control.
- **Riparian Buffers –** Areas of trees, shrubs, and grasses adjacent to streams or drains help filter runoff by trapping sediments, nutrients, and pesticides. Riparian buffers also provide wildlife habitat.
- **Livestock Access –** This practice restricts or controls livestock access to surface waters to reduce sediment and nutrient nonpoint source pollution.

affect only small areas. Since these acquisition programs only can affect a small portion of agricultural lands, stewardship is increasingly considered by governmental and nongovernmental organizations for protecting natural resources while keeping the lands in productive private ownership.

A range of private and public programs and initiatives already exist that fit the stewardship model (see Box 2-2). Many public programs provide technical assistance on what crops to plant, and how to plant, cultivate and irrigate them. Others provide technical help on wildlife-friendly farming techniques for wildlife and aquatic ecosystems. Additional types of programs cover soil, water, and habitat conservation planning. These efforts can identify suitable areas for farming and habitat management. Urban planning programs can also be used to avoid agricultural land fragmentation and permanent loss of valuable agricultural land because of urban development (see the urban land use management strategy). And finally, there are programs that limit or cease commercial agricultural use to promote wetlands and other wildlife sensitive areas, while keeping lands in private ownership and stewardship.

The following examples describe a range of stewardship programs.

The CALFED Working Landscapes Subcommittee

The Bay-Delta Public Advisory Committee established a Working Landscapes Subcommittee to advise it in the formulation of a working lands management approach for Bay-Delta Programs (see Box 2-3). The Working Landscape Subcommit-

Box 2-2 Initiatives that Exemplify Agricultural Lands Stewardship Strategy

- **Proposition 50 Ecosystem Restoration Program's Proposed Working Landscapes Grants.** Allocated not less than $20 million "for projects which assist farmers in integrating agricultural activities with ecosystem restoration." These funds could be used as "matching funds" with the Farm Bill, thus leveraging State money with federal money.
- **USDA Natural Resources Conservation Service**
  - **Conservation Security Program** offers incentives and rewards to growers who implement resource conservation plans for parts or all of their lands.
  - **Conservation Technical Assistance Program** provides technical assistance to design and implement stewardship practices.
  - **Wetland Reserve Program** offers incentives to restore wetlands in order to replace marginal croplands to help restore the biological diversity of plant and animal species, particularly, migratory waterfowl.
  - **Grasslands Reserve Program** provides rental payments and easements on working grasslands in exchange for protection against conversion to other land uses.
  - **Farm and Ranchland Protection Program** is used to secure easements to prevent conversion from agricultural land to urban land use.
  - **Wildlife Habitat Incentives Program** provides up to 75 percent cost-share to reimburse participants for installing practices beneficial to wildlife.
- **Department of Water Resources Flood Protection Corridor Program.** Grants for nonstructural flood management that enhance wildlife habitat or protect agricultural uses on private lands.
- **Department of Fish and Game Private Lands Management Program.** Pays ranchers and farmers to improve habitat for wildlife through fishing and hunting.
- **Wildlife Conservation Board Rangeland, Grazing Land and Grassland Protection Act of 2002.** Grants to prevent rangeland conversion to more intensive uses, and to improve grazing and wildlife.
- **The Farmland Mapping and Monitoring Program (FMMP).** Managed by the DOC, produces maps and statistical data used for analyzing impacts on California's agricultural resources. The maps are updated every two years with the use of aerial photographs, a computer mapping system, public review, and field reconnaissance.

tee seeks to provide the committee with creative and practical strategies that: (1) enhance the sustainability of California agriculture; and (2) provide for participation of local communities, landowners and managers; while (3) significantly fulfilling the CALFED Record of Decision to restore ecological health and improve water management for beneficial use of the Bay-Delta system while minimizing harm to agriculture.

The Farm Security and Rural Investment Act of 2002

The reauthorized national Farm Bill 2002 provides several new and traditional agricultural conservation programs that exemplify an agricultural lands stewardship strategy. All programs are voluntary. Many programs may include technical assistance, financial incentives, or temporary and permanent set-aside payments for various purposes.

Potential Benefits

Agricultural lands stewardship can be included as an integral component of regional integrated resource planning, including watershed planning and implementation. Agricultural lands stewardship can use stewardship practices to protect the health of environmentally sensitive lands, recharge groundwater, improve water quality, provide water for wetland protection and restoration, reduce costs to the State for flood management, and aid riparian reforestation and management projects. Lands can also be managed to improve water management, urban runoff control, water storage, conveyance and for groundwater recharge. These stewardship practices are attractive since they don't rely on construction of major facilities.

Agricultural land stewardship can be part of a regional strategy of urban growth management. Agricultural lands provide public benefits for floodplain management, scenic open space, wildlife habitat, and defined boundaries to urban growth. Stewardship provides the rural counterpart to urban efforts to encourage more water efficient development patterns. It also can minimize fragmentation of agricultural lands by development that can decrease productivity and harm the ecosystem.

Potential Costs

Governmental and nongovernmental entities are seeking ways to secure funds for conservation practices that can be part of stewardship. In general, there is agreement by economists on three questions: 1) What are the direct costs for supporting stewardship programs? 2) What are the common ways to measure the costs for the wide range of environmental values? 3) What current level of investment is needed to sustain stewardship for the long term?

Developing stewardship costs is similar to estimating costs of managing lands to avoid environmental impacts such as air and water pollution, or to provide wildlife habitat or secure food and fiber production. Stewardship is a way of doing business and it should be a part of an economic model that shows a return on investment by placing a value on healthy communities and their quality of life. In addition, agricultural lands stewardship helps avoid costs associated with urban land use. Not only are there cost savings by avoiding expansion of infrastructure, but there are avoided costs for flood damage reduction measures and urban runoff. These costs have not been quantified for broad reference and application.

Some legislative proposals are seeking to provide annual payments for conservation benefits that may be part of private lands management programs. Experience and recent trends suggests that many California agricultural lands owners may participate in some agricultural lands stewardship programs if the annual rents they receive are about $100 to $200 per acre. Based on a DWR preliminary estimate, agricultural land use practices in California could cost about $5.3 billion by year 2030.[1]

Box 2-3 BDPAC Working Landscapes Approach

The working landscape is defined as an economically and ecologically vital and sustainable landscape where agricultural and other natural resource-based producers generate multiple public benefits while providing for their own and their communities' economic and social well-being.

[1] Cost estimate = $5.3 billion, determined as follows: Total cost is the sum of three components: (A) financial assistance, (B) technical assistance and (C) land acquisition where A = State of California estimate of unmet federal need for conservation cost-share programs = ($80 million/yr) X (25 yr until 2030) = $2 billion; B = State of California estimate of unmet need for field staff = (800 persons) X ($90,000/yr/person) X (25 yr until 2030) = $1.8 billion; C = conservation easements on about 9% of 11.4 million total acres of farmland = (1 million acres) X $1500/acre = $1.5 billion; A + B + C = $2 billion + $1.8 billion + $1.5 billion = $5.3 billion.

Major Issues Facing Agricultural Lands Stewardship

There are major issues related to improving agricultural lands stewardship in California. There are issues about mixing economic endeavors with environmental goals and economic markets. Increased focus on this strategy is necessary to implement regional integrated resource planning and management, and demonstrate to the public the measurable benefits of stewardship.

Landowner Concerns

Landowners are concerned that environmental programs that help growers improve habitat might attract more threatened and endangered species affecting landowners use of land. Thus some landowners are reluctant to be involved with government agencies, even though some of these agencies might help landowners to comply with real regulatory requirements. Federal Endangered Species Act assurances can only be granted by the U.S. Fish Wildlife Service and the National Marine Fisheries Service. In order to determine what type of species must be covered and possible protective measures that may be required, surveys are necessary to determine what species are present. This only increases landowner concerns that they will be subject to increased restrictions if the presence of endangered species is verified on their property.

Some landowners question how they can adequately maintain their privacy and, at the same time, satisfy the public need for information of farm activities supported by public resources. In addition, there is landowner confusion regarding what type of assurances can be provided. A perspective is that the economic return from certain land stewardship programs may often be less than the return from other options for land use, especially when urban development is an option.

Lack of Information

There is a lack of scientific, economic, social and environmental studies and monitoring of agricultural lands stewardship programs to evaluate their merits for ecosystem restoration, water quality, and agricultural economics for large and small agricultural operations. There are conflicting reports about the compatibility of certain agricultural lands stewardship and ecosystem restoration programs. In order to justify public investment in stewardship, there must be accountability in terms of monitoring.

Complex Regulations and Programs

Institutional regulations and programs are complex and sometimes conflict. Agricultural landowners may be discouraged when developing a stewardship program for multiple purposes such as water and soil conservation, ecosystems restoration, floodplain and wetlands management, water quality and land use planning. The regulations may seem intrusive to the private landowner but essential for those responsible for environmental protection and restoration programs.

Funding

California has traditionally received proportionally less funding for USDA Farm Bill's conservation provisions relative to its agricultural standing, the value of the threatened resources and the population served. Although California farmers and ranchers provide more than 13 percent of the nation's food and fiber, they historically receive less than 3 percent of federal farm conservation funding.[2] Commodity support programs influence stewardship management. California is dominated by specialty crops rather than traditional price-supported commodity programs. The funding inequities of the Farm Bill will become increasingly apparent in the future as production of California cotton, alfalfa, irrigated pasture, and possibly rice decreases and as specialty crops increase.

Regional Cooperation

Without regional cooperation, private landowners may be frustrated in reaching their management goals by adjacent operations or watershed activities that do not contribute to better management for environmental functions and values. These values include protecting and reestablishing riparian corridors or water quality within a watershed.

State Policy Goals

In general, land use is a local planning issue subject to local regulation. Statewide planning goals or restrictions may be seen as an intrusion on local governmental powers. Second, is the conflict between private property and public commitments? Many landowners prefer programs such as the Williamson Act because these are temporary land-use restrictions that landowners can ultimately "opt out" of if they later decide to sell land to development and the asking price justifies the cancellation penalty. As a result, many landowners are wary that they may lose future economic opportunities by committing to permanent restrictions. Likewise, the public may be

[2] Conservation Reserve Enhancement Program (CREP), Environmental Quality Incentives Program (EQIP), Wildlife Habitat Incentive Program (WHIP), Wetlands Reserve Program (WRP) and Conservation Security Program (CSP).

unwilling to fund the necessary incentive (rental, technical assistance, etc.) programs essential to successful stewardship without a clear understanding of long-term benefits from such programs.

Recommendations to Facilitate Agricultural Lands Stewardship

The following recommendations can help facilitate an agricultural lands stewardship strategy:

1. The State should collaborate with rural and agricultural organizations and coordinate with local RCDs to provide private landowners financial incentives and access to educational resources through public and nongovernmental programs that demonstrate the benefits of agricultural lands stewardship and ecosystem restoration.
   - Demonstrate that stewardship programs can help landowners be good stewards without compromising landowner rights.
   - The program should emphasize that it is voluntary, flexible, and incentive-based strategy.
   - Provide "success" stories to resource managers and environmental organizations to demonstrate that private stewardship can achieve desired environmental benefits.
   - Provide economic information regarding the advantages and disadvantages of land stewardship to compare with other investment choices.

2. The State should create a directory that identifies the appropriate State agency for coordination between the State and federal agencies. Under the State agency coordination leadership, the pertinent agencies should provide staff support for land owners participating in multiple environmental goals and local conservation initiatives. The agencies include the California Department of Conservation's Watershed Grant Coordinator Program, Resource Conservation District Assistance Program, California Department of Fish and Game, USDA Natural Resource Conservation Service programs, California Conservation Partnership Program, and U.S. Fish and Wildlife Service. The agencies should identify opportunities to further institutional coordination, assist landowners in applying for grants funding, and help stakeholder planning and implementation.

   - Ensure consistent, dependable and adequate funding for stewardship assistance, especially the USDA Natural Resources Conservation Service, the agency that has traditionally provided this kind of assistance.
   - Assist landowners with endangered species issues.
   - Document environmental results with accepted standards, criteria and protocol while respecting private land ownership.

3. The State should help landowners implement agricultural lands stewardship plans. Greater State participation would help direct federal funds toward landowner participation and technical assistance.

4. The State should evaluate the socioeconomics effect of agricultural lands stewardship, including a comprehensive assessment of:
   - Regional changes in agricultural production inputs and farm income (including income received from land and water payments) as the result of crop-idling.
   - "True cost accounting" of costs and benefits over long-term and including maintenance for stewardship management approaches.
   - Habitat restoration (including financial on-farm investments and increased recreational opportunities).
   - Annual maintenance expenditures

5. The State should increase scientific studies to assess the environmental, ecosystem restoration and agricultural benefits of agricultural lands stewardship programs. The State should continue research on sustainable agricultural-based economies. The State should continue monitoring and assessing agronomic beneficial effects, including improved air and water quality, and habitat restoration and their associated costs.

6. The State should develop an agricultural lands stewardship performance assessment program based on measurable changes, such as improved water quality, lessened agricultural land runoff (thus reducing local flooding and recharging ground water) and improved habitat.

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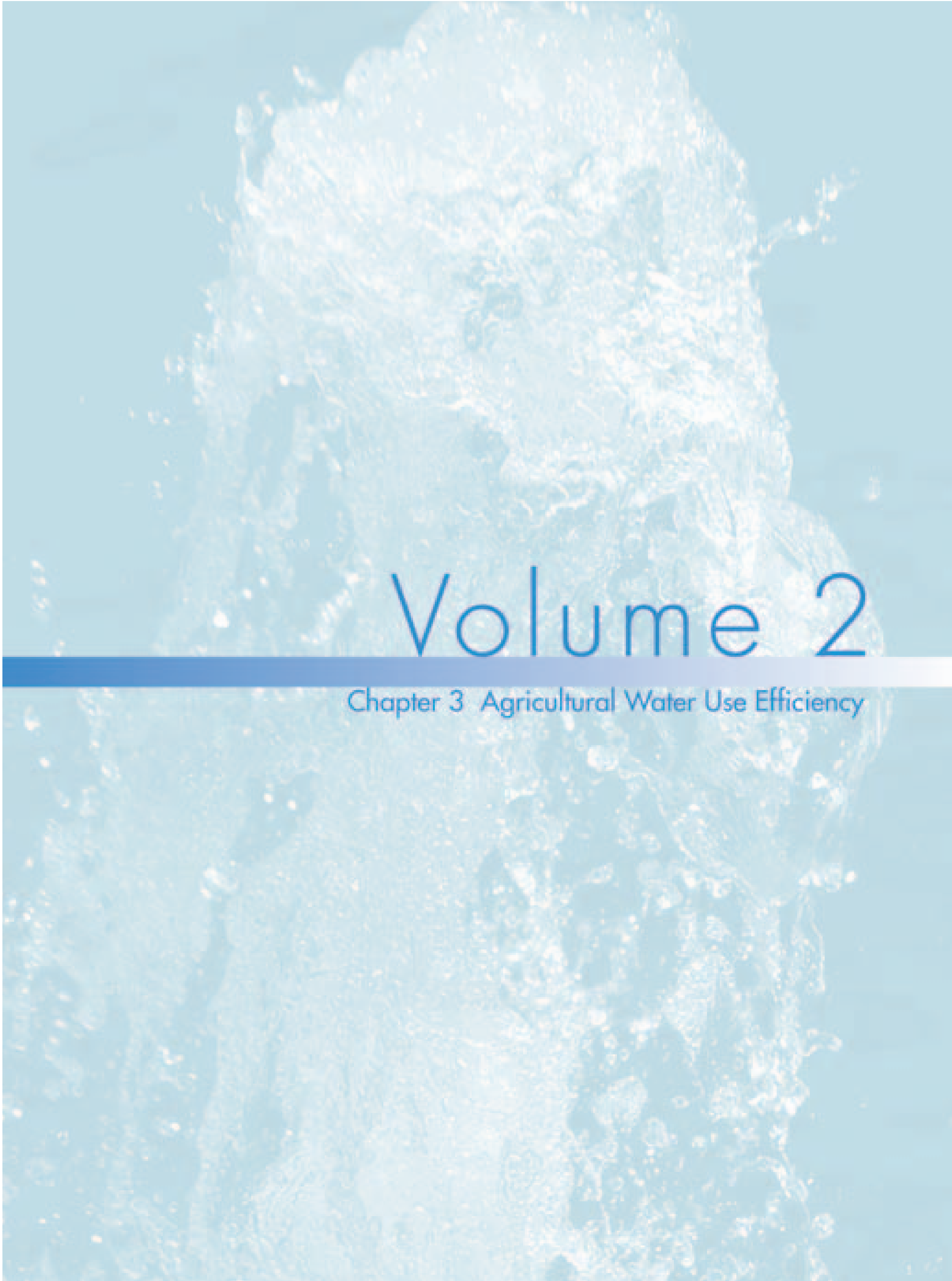


Volume 2

Chapter 3 Agricultural Water Use Efficiency

In California, growers and water suppliers implement state-of-the-art design, delivery, and management practices to increase production efficiency and conserve water.

Chapter 3 *Agricultural Water Use Efficiency*

Agricultural water use efficiency involves improvements in technologies and management of agricultural water that result in water supply, water quality, and environmental benefits. This narrative discusses efficiency improvements such as on-farm irrigation equipment, crop and farm water management, and water supplier distribution systems.

Current Agricultural Water Use Efficiency Efforts in California

Agriculture is an important element of California's economy, generating $27.6 billion in gross income in 2001 according to the California Agricultural Statistics Service. In 2000, California irrigated an estimated 9.6 million acres of cropland with about 34.2 million acre-feet of applied water.

In California, growers and water suppliers implement state-of-the-art design, delivery, and management practices to increase production efficiency and conserve water. As a result, they continue to make great strides in increasing the economic value and efficiency of their water use. One indicator of agricultural water use efficiency improvement is that agricultural production per unit of applied water (tons/acre-foot) for 32 important California crops increased by 38 percent from 1980 to 2000. Another indicator is that inflation-adjusted gross crop revenue per unit of applied water (dollars/acre-foot) increased by 11 percent between 1980 and 2000.

The Agricultural Water Suppliers Efficient Water Management Practices Act of 1990 (AB 3616) and the Federal Central Valley Project Improvement Act of 1992 (CVPIA) established guidance for improving agricultural water use efficiency. As of September 2005, the Agricultural Water Management Council unites, through a Memorandum of Understanding (MOU), 74 agricultural water suppliers and three environmental organizations in an effort to improve water use efficiency through implementation of efficient water management practices. The council recognizes and tracks water supplier water management planning and implementation of cost-effective efficient water management practices through a review and endorsement procedure. The signatory agricultural water suppliers voluntarily commit to implement locally cost-effective management practices (see Box 3-1). The agricultural water suppliers represent more than 4.6 million acres of irrigated agricultural land. Some signatories to the MOU submit water management plans, most of which are endorsed by the council. Additionally, 24 signatories subject to federal CVPIA planning requirements have council-endorsed plans.

Growers invest in on-farm water management improvements to stay economically competitive. Likewise, local water suppliers invest in cost-effective, system-wide water management improvements in order to provide quality service at a fair and competitive price. In addition to water savings, efficiency measures can provide water quality and flow-timing benefits. The CALFED Program's Quantifiable Objectives (QOs) and Targeted Benefits — which can be local, regional, or statewide — are numeric targets of water savings that address CALFED objectives of water supply reliability, water quality, and ecosystem improvements.

Substantial financial support for research, development and the demonstration of efficient water management practices in agriculture comes from the agricultural industry and State and federal efforts. Support also comes from the early adopters of new technology who often risk their crops, soils, and money when cooperating to develop and demonstrate technology innovations. Further investments in research and demonstration are critical, especially in support of university-based research, field station studies, and cooperative extension demonstration projects.

Improvements in agricultural water use efficiency primarily occur from three activities:

- **Hardware** – Improving on-farm irrigation systems and water supplier delivery systems
- **Water management** – Improving management of on-farm irrigation and water supplier delivery systems
- **Crop water consumption** – Reducing non-beneficial evapotranspiration

Hardware Upgrades

Due to water delivery system limitations, growers are often unable to apply the optimal amount of irrigation water. Water delivery system improvements such as integrated supervisory control and data acquisition systems, canal automation, regulating reservoirs, and other hardware and operational upgrades, can provide flexibility to deliver water at the time, quantity, and duration required by the grower. At the on-farm level, most orchards and vineyards, as well as some annual fruits and vegetables, are irrigated using pressurized irrigation

Box 3-1 Agricultural Water Management Efficient Water Management Practices (EWMPs)

The Agricultural Water Management Council has three classifications of EWMPs as follows:

List A - Generally Applicable Efficient Water Management Practices—Required of all signatory water suppliers

1. Prepare and adopt a water management plan
2. Designate a water conservation coordinator
3. Support the availability of water management services to water users
4. Where appropriate, improve communication and cooperation among water suppliers, water users, and other agencies
5. Evaluate the need, if any, for changes in policies of the institutions to which water supplier is subject

List B - Conditionally Applicable Efficient Water Management Practices – Practices Subject to Net Benefit Analysis and Exemption from Analysis

1. Facilitate alternative land use (drainage)
2. Facilitate use of available recycled water that otherwise would not be used beneficially
3. Facilitate the financing of capital improvements for on-farm irrigation systems
4. Facilitate voluntary water transfers that do not unreasonably affect the water user, water supplier, the environment, or third parties
5. Construct improvements (lining and piping) to control seepage from ditches and canals
6. Within operational limits, increase flexibility in water ordering by, and delivery to, the water users
7. Construct and operate water suppliers' spill- and tail-water recovery systems
8. Optimize conjunctive use of surface and groundwater.
9. Automate canal-control structures

List C - Practices Subject to Detailed Net Benefit Analysis without Exemption

1. Water measurement and water use report
2. Pricing or other incentives

For detailed information on the Agricultural Water Management Planning and Implementation process, implementation of EWMPs, Net Benefit Analysis and schedules, see the Memorandum of Understanding at AWMC Web site, www.agwatercouncil.org/aboutusmain.htm

Table 3-1 Trends in irrigation method area (in million acres)

Irrigation method	1990		2000		Change from 1990 to 2000
	Area	% of Total	Area	% of Total	(change in acreage)
Gravity (furrow, flood)	6.5	67	4.9	51	- 16
Sprinkler	2.3	24	2.8	29	5
Drip/micro	0.8	9	1.9	20	11
TOTAL	9.6	100	9.6	100	

Source: DWR

systems. Almost all trees and vines established since 1990 are irrigated using micro-irrigation. Between 1990 and 2000, the crop area under micro-irrigation in California grew from 0.8 million to 1.9 million acres, a 138 percent increase (see Table 3-1 and Box 3-2).

Many growers use automated irrigation systems for irrigation, fertilizer application, and pest management. Advanced technologies include Geographic Information System (GIS), Global Positioning System (GPS) and satellite crop and soil moisture sensing systems. These technologies allow growers to improve overall farm water management.

The use of pressurized irrigation systems, such as sprinkler, drip, and micro-spray, in addition to being energy intensive, often requires modernization of water supplier delivery systems to provide irrigation water at the time, quantity, and duration required by the grower. Increasingly, water suppliers are upgrading and automating their systems to enable accurate, flexible, and reliable deliveries to their customers. Also, suppliers are lining canals, developing spill recovery and tail water return systems, employing flow regulating reservoirs, improving pump efficiency, and managing surface water conjunctively with groundwater. With the advancement of both water supplier and on-farm water management systems, there is potential to improve irrigation efficiencies at both on-farm and water supplier levels.

Growers continue to make significant investments in on-farm irrigation system improvements, such as lining head ditches and using micro-irrigation systems. Many growers take advantage of mobile laboratory services to conduct in-field evaluation of irrigation systems. Once considered innovative technologies, these are now standard practice. In terms of future improvements, the California Polytechnic State University, San Luis Obispo, Irrigation Training and Research Center estimates that an additional 3.8 million acres could be converted to precision irrigation such as drip or micro-spray irrigation. While this will not reduce crop water consumption, it can improve the uniform distribution of water and reduce evaporation and non-beneficial evapotranspiration, thus allowing more efficient use of water. Research on drip irriga-

Box 3-2 Example of Irrigation Efficiency Improvement

Kern County Water Agency reports significant improvements in irrigation efficiency. An analysis of data in 1986 compared to 1975 showed an 8 percent improvement (from 67 percent in 1975 to 75 percent in 1986). This improvement reduced the total applied water use in the San Joaquin Valley portion of Kern County by about 250,000 acre-feet, enough water to irrigate about 70,000 acres. Since 1986 Kern County has added 61,500 acres of trees and vines. These now make up 37 percent of the total irrigated crop area. Nearly all of this new crop area has low volume drip irrigation systems installed. KCWA estimates the overall on-farm water use efficiency now is about 78 percent. Note that the remaining 22 percent constitutes leaching requirement, irrigation system distribution nonuniformity, and cultural practices, which includes both recoverable and/or irrecoverable flows.

tion of alfalfa has shown an applied water reduction of two to three percent with yields increasing from 19 to 35 percent, an increase in productivity of 30 percent with the same amount of applied water. Conversion of traditional irrigation systems to pressurized systems and installation of advanced technologies on water supplier delivery systems require more investment in facilities as well as use of additional energy that increases farm production costs and water supplier operational costs.

Water Management

Both on-farm and water supplier delivery systems must be managed to take advantage of new technologies, science, and hardware. Personal computers connected to real-time communication networks and local area networks allow transmission of flow data to a centralized location. These features enable water supplier staff to monitor and manage water flow and to log data. With such systems, the water supplier staff spends less time manually monitoring and controlling individual sites, allowing them to plan, coordinate system operation, and reduce costs. Such systems improve communications and provide for flexible water delivery, distribution, measurement, and accounting.

Some of today's growers use satellite weather information and forecasting systems to schedule irrigation. Many growers employ evapotranspiration and soil moisture data for irrigation scheduling. Users generate more than 70,000 inquiries per year to the California Irrigation Management Information System (CIMIS), the Department of Water Resources' weather station program that provides evapotranspiration data. Universities, water suppliers, and consultants also make this information available to a much wider audience via newspapers, Web sites, and other media. Growers use many other water management practices. Furrow, basin, and border irrigation methods have been improved to ensure that watering meets crop requirements while limiting runoff and deep percolation. Growers use plastic mulch to reduce non-essential evaporation of applied water.

Reducing Evapotranspiration

Evapotranspiration is the amount of water that evaporates from the soil and transpires from the plant. Growers can reduce evapotranspiration by reducing unproductive evaporation from the soil surface, eliminating weed evapotranspiration, shifting crops to plants that need less water, or reducing transpiration. In addition, growers deficit irrigate their crops during water short periods and for agronomic purposes (see Box 3-3).

Potential Costs and Benefits of Agricultural Water Use Efficiency

The CALFED Water Use Efficiency Technical Appendix of the CALFED Record of Decision (ROD) estimates the costs and benefits of water savings. Recently, the California Bay Delta Authority (CBDA) sponsored a study that estimates the costs and benefits of water use efficiency as a part of the CBDA Year Four Comprehensive Report (Year Four Report). These two estimates are based on different approaches and assumptions. The ROD's potential costs and benefits are based on assumed on-farm efficiency improvements of 85 percent within each hydrologic region and consider total irrigated crop area,

Box 3-3 Regulated Deficit Irrigation

Some growers use regulated deficit irrigation (RDI) to stress trees or vines at specific developmental stages to improve crop quality, decrease disease or pest infestation, reduce production costs, while maintaining or increasing profits. Conventional irrigation management strategy has been to avoid crop water stress. Research on RDI began in California in the 1990s on tree and vine crops. Initial results show potential for reducing evapotranspiration while increasing or maintaining crop profitability and allowing optimum production.

Wine grapes are a clear example: Mild stress imposed through the growing season decreases canopy growth, but produces grapes with higher sugar content, better color and smaller berries with a higher skin to fruit-volume ratio. This is a very common practice in the premium wine regions of California.

RDI has been primarily used as a production management practice and the extent of its application in California has not been quantified. Before RDI can be applied to other crops, information on its costs, risks, long-term impacts, and potential benefits including water savings must be determined. Once that is done, practical guidelines for growers on how to initiate, operate, and maintain RDI should be developed and disseminated. (See Volume 4 Reference Guide for details on RDI.)

crop water use, applied water, and depletions. The Year Four Report estimates are based on crop water use, irrigated crop area, irrigation system type, and applied water within each Water Plan planning area. It uses cost and performance information for on-farm and water supplier improvements to estimate costs, considers various levels of funding and local implementation, and accounts for quantifiable objectives developed for the CALFED Bay-Delta Program's Water Use Efficiency Element. In addition, it includes an estimate of potential water use reduction from implementing a moderate level of regulated deficit irrigation.

Potential Benefits

The ROD estimates that efficiency improvements will result in a water savings (reduction in irrecoverable flows also referred to as net water use) ranging between 120,000 to 563,000 acre-feet per year by 2030. The study also showed a 1.6 million acre-foot per year reduction in applied water (combined recoverable and irrecoverable flows) that provides environmental and crop production benefits. Additionally, water use efficiency measures in the Colorado River Hydrologic Region will reduce irrecoverable flows by 68,000 acre-feet per year (at a cost of $135.65 million) by lining the All American Canal and 26,000 acre-feet per year (at a cost of $83.65 million) by lining the Coachella Branch Canal for a total of 94,000 acre-feet per year. The Quantification Settlement Agreement (QSA) will result in 413,000 acre-feet per year of agricultural water use efficiency by the Imperial Irrigation District in the Colorado River Hydrologic Region. However, the water conserved under the QSA will not result in new water supplies for California; rather it is a step to help California water users reduce their use of Colorado River water by 800,000 acre-feet per year – from 5.2 to 4.4 million acre-feet per year. (For details, see Volume 3, Chapter 11, Colorado River Hydrologic Region and following Web site: www.usbr.gov/lc/region/g4000/crwda/index.htm.

Benefits resulting from implementation of other advanced technologies in hardware and water management, and in crop evapotranspiration, crop shifts, and reducing crop transpiration have not been quantified for this narrative.

The Year Four Report study used Water Plan Update land and water use data for the year 2000 and a DWR survey of irrigation methods used by growers in 2000. The analysis was conducted based on a 27-year implementation horizon (2003-2030) at the on-farm and local water supplier level. The Year Four Report estimates do not include the potential reduction of 94,000 acre-feet per year of irrecoverable flow in the Colorado River Hydrologic Region, because that region's ongoing conservation and transfer activities are outside the CALFED Program's solution area. On-farm improvements were based on natural replacement from lower to higher performing systems over time as well as various state funding levels. Water supplier improvements were based on the implementation of efficient water management practices and various state funding levels.[1] Table 3-2 presents the reduction in recoverable and irrecoverable flows at both the on-farm and water supplier levels. The cost information in Table 3-2 represents the State's investment in water use efficiency actions that generate statewide benefits.

Water use efficiency estimates at the water supplier level are based on cost and performance of supplier management changes and infrastructure improvements. A regional baseline of water supplier improvements was developed based on water availability and knowledge of local delivery capabilities and practices. In addition it was assumed that all locally cost-effective efficient water management practices are implemented. The initial investment for improvements is allocated for management changes that provide an improved level of delivery service – mainly through additional labor and some system automation. Higher levels of water supplier delivery system performance are achieved through infrastructure improvements such as regulating reservoirs, canal lining, additional system automation, and spill prevention.

At the water-supplier level, most of the benefit of water use efficiency is with recoverable flows. However, since recoverable flows, especially surface return flows, are typically being used by downstream farming operations, the location of the water diversion in the basin is critical for determining if implementing a water use efficiency measure would adversely reduce the supply of downstream agricultural water users. Consequently, many consider the reduction of irrecoverable flows (or net water use) a better estimate of potential agricultural water use efficiency.

On-farm water use efficiency estimates are based on cost and performance information for feasible irrigation systems. Depending on crop type, irrigation systems can include various forms of surface irrigation (furrow and border strip), sprinkler irrigation, or drip irrigation. The performance of any irrigation system also depends on how well it is managed. For a given crop, the irrigation system and management will determine

[1] The potential savings estimated in the Year Four Report are based on a set of specific assumptions about the distribution and effective use of investments in agricultural water use efficiency. See the *CBDA Draft Year Four Water Use Efficiency Comprehensive Report* for details on those assumptions.

Table 3-2 On-farm and water supplier recoverable and irrecoverable flow reductions. Estimated to be fully realized by 2030

Investment Level	Investment Area	Annual State Spending[1]	Reductions in Irrecoverable Flows[2]	Reductions in Recoverable Flows[2]	Quantifiable Objective[3]
		$ Million/year	thousand acre-feet per year		
1	On-farm[4, 5]	0	33	147	507 (total flow for 11 major rivers in the Bay-Delta watershed, does not include the San Joaquin River)
	Water Supplier	2.9	1	4	
2	On-farm	7.5	93	545	
	Water Supplier	7.5	10	20	
3	On-farm	15	143	876	
	Water Supplier	15	48	72	
4	On-farm	25	196	1208	
	Water Supplier	25	105	134	
5	On-farm	50	287	1723	
	Water Supplier	50	222	188	
6	On-farm	75	346	2006	
	Water Supplier	75	275	196	

1. Total spending from all sources used for improvements that are not locally cost-effective. For investment levels 2-6, the annual dollar amount includes local spending induced by the availability of state or federal grants.
2. Estimates do not include the Klamath Project (North Coast Region) or Imperial Valley (Colorado River Region).
3. Complete description of Quantifiable Objectives is found at www.calwater.ca.gov
4. On-farm irrecoverable flows include an annual savings of 143,000 acre-feet per year due to regulated deficit irrigation.
5. Much of the on-farm savings would not be achieved without the corresponding water supplier level spending. Water supplier improvements conserve water themselves and are required to enable much of the on-farm conservation.

the water use characteristics: how much of the applied water is used beneficially and how much is irrecoverable. Irrecoverable flows include those to transpiration, saline sinks and non-beneficial evaporation. In Table 3-2, the reduction in irrecoverable flows at investment level 1 is due to natural replacement of irrigation systems over the horizon of the projections. Recoverable flows encompass surface runoff and deep percolation to usable water bodies. The recoverable flow results in Table 3-2 are based on the Quantifiable Objectives that express in-stream flow needs for Bay-Delta tributaries. Although recoverable and irrecoverable flow reductions are reported separately for on-farm and water suppliers, it is not appropriate to assign benefits solely to on-farm or water suppliers due to the strong connection between on-farm recoverable flows and water supplier efficiency improvements.

Environmental benefits of water use efficiency actions are the improvement in aquatic habitat through changes in in-stream flow and timing. Additional benefits may include water quality improvements by reducing thermal loading, subsurface drainage water, and contaminant loads. Growers may receive water quality benefits by complying with pollutant reduction rules under the State's total maximum daily load requirements. However, depending on the timing of flow changes, improvements in water use efficiency can cause negative environmental effects, such as reduced runoff to downstream water bodies and increased concentration of pollutants in drain water unless the drainage water contaminants are isolated and properly disposed of. The Quantifiable Objectives flows in Table 3-2 represent the aggregate in-stream Bay-Delta watershed flow needs that can potentially be met through water use efficiency actions. When comparing the recoverable flows in Table 3-2 to the Quantifiable Objectives flows it is important to remember that the in-stream flow needs are location and time specific – thus an acre-foot to acre-foot comparison is not appropriate.

Potential Costs

The ROD estimates the cost of 563,000 acre-feet net water savings at $35 to $900 per acre-foot. The total cost of this level of agricultural water use efficiency to year 2030 is estimated at $0.3 billion to $2.7 billion, which includes $220 million for lining the All American Canal and Coachella Branch Canal.[2]

The Year Four Report cost estimate for water use efficiency improvements are summarized in Table 3-2. The water supplier improvements are assumed required to achieve on-farm improvements. The irrecoverable flow reduction estimates range from 34,000 to 620,000 acre-feet per year at a cost of $2.9 million to $150 million per year, respectively, for on-farm and water suppler level improvements. The Year Four Report estimates do not include potential water use reductions in the Klamath Project or Imperial Valley. Efficiencies calculated for the Year Four Report are lower than the ROD estimates because rice irrigation systems can only achieve about 60 percent efficiency on an individual field basis and rice acreage is significant in certain hydrologic regions (the ROD assumed that irrigation efficiency improves to an average value of 85% in every hydrologic region). Marginal costs of irrecoverable flow reduction are shown in Figure 3-1.

The cost of achieving the 620,000 acre-feet per year of irrecoverable flow reduction estimated in the Year Four Report over 25 years (about $3.75 billion), plus the cost of 94,000 acre-feet per year of water use reductions resulting from lining the All American and Coachella Branch canals (a total of 714,000 acre-feet per year) will total about $4 billion, expressed in 2004 dollars. It should be noted that costs and flow for each investment level identified in Table 3-2 includes costs and water use reductions of all previous investment levels.

The Year Four Report estimates show increasing statewide average seasonal application efficiency as a function of annual investment (Figure 3-2).

Major Issues Facing Additional Agricultural Water Use Efficiency

Funding

Funds dedicated to water use efficiency have fallen below estimates of the 2000 CALFED Record of Decision that called for an investment of $1.5 billion to $2 billion from 2000-2007. The CALFED Framework For Agreement stated that State and federal governments would fund about 50 percent (25 percent each), with local agencies paying the remaining 50 percent of CALFED water use efficiency activities.

Although the need is great, small and disadvantaged communities may not be able to apply for State and federal grants, because of the difficulty of the application and grant management processes for what are often limited funds. In addition, such water suppliers rarely have the technical and financial abilities to develop plans or implement expensive water management practices.

For some water suppliers, funding for water use efficiency comes from the ability to transfer water, such as in Colorado River region. While transfers to urban areas may reduce the amount of water available to grow crops, they are expected to play a significant role in financing future water use efficiency efforts.

Implementation

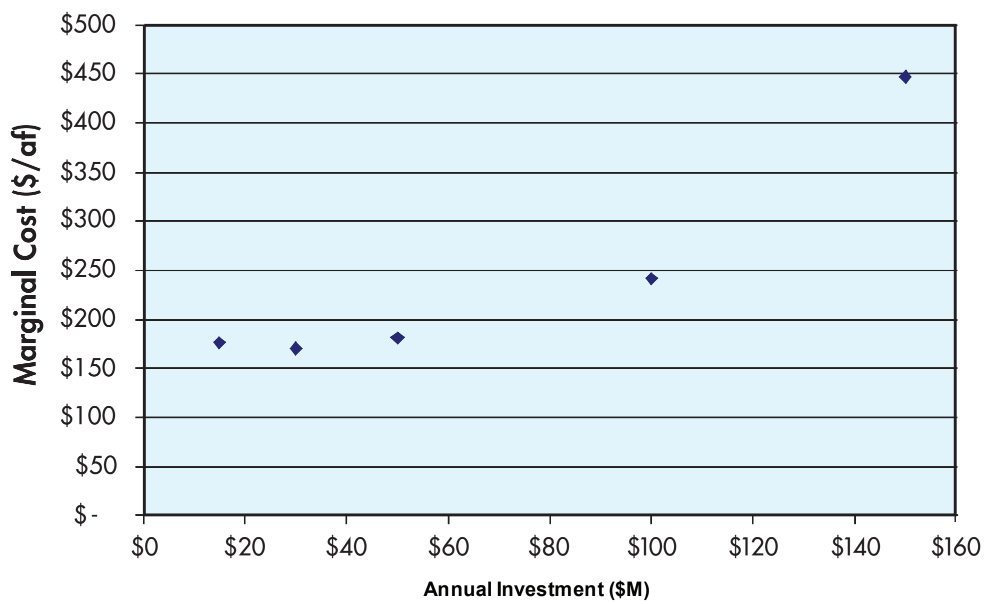
Implementation of agricultural water use efficiency depends on many interrelated factors. Farmers strive to optimize agricultural profits per unit of land and water without compromising agricultural economic viability, water quality, or the environment. Success depends not only on availability of funds but also on technical feasibility and cost-effectiveness, availability of technical assistance, and ability and willingness of growers, the irrigation industry, and water suppliers. Opportunities exist through CALFED to implement efficiency measures beyond efficient water management practices to provide water quality and flow timing benefits for the local water supplier and to provide regional or statewide benefits. Designing and installing efficient irrigation and water distribution systems will not necessarily result in improved efficiency if the systems are not well managed.

Reducing evaporation requires precise application of water. Stressing crops through regulated deficit irrigation (RDI) is one approach which requires careful scheduling and application of water and may have additional costs and adverse impact on crop quality or soil salinity. In the case of RDI, research is needed to evaluate the level of current practices, extent of implementation of these practices, and quantification of RDI benefits and impacts.

Many growers and irrigation districts believe that implementing efficiency measures could affect their water rights. They believe

[2] The cost estimates are derived from potential on-farm and water supplier efficiency improvements associated with savings in irrecoverable flows. Details of estimates and assumptions are in the CALFED WUE Program Plan (Final Programmatic EIS/EIR Technical Appendix- July 2000).

Figure 3-1 Marginal cost of irrecoverable flow reduction



Shown is marginal cost of reducing irrecoverable agricultural water uses by increasing agricultural water use efficiency. Studies show marginal costs relatively constant at about $175 per acre-foot with annual investments up to $50 million and about $450/af with annual investments at about $150 million.

that conserved water may be used by others, causing a loss of rights to the conserved water. This belief is a factor that may impede implementation of water use efficiency strategies.

Measurement, Planning, and Evaluation

Lack of data is an obstacle for assessing irrigation efficiencies and planning further improvement. The State lacks comprehensive data on the cropped area under various methods of irrigation, applied water, crop water use, irrigation efficiency, water savings, and the cost of irrigation improvements per unit of saved water. Collection, management and dissemination of data to growers, water suppliers, and water resource planners are necessary for promoting increased water use efficiency. A concern identified by some members of the Advisory Committee is a lack of statewide guidance to assist regions and water suppliers to collect the data needed for future Water Plan Updates in a usable format.

The Independent Panel on the Appropriate Measurement of Agricultural Water Use (www.Calwater.ca.gov) convened by the CBDA made specific recommendations for measurement of water supplier diversions, net groundwater use, crop water consumption, and aggregate farm gate deliveries. In addition, the panel recommended increased efforts to measure water quality, return flows, and stream flow.

Resource Requirements

Water supplier infrastructure improvements and the increasing use of pressurized irrigation systems require additional energy resources such as electricity, gas, and diesel. Pressurized systems also require pipelines, pumps, filters and filtration systems, and chemicals for cleaning drip systems.

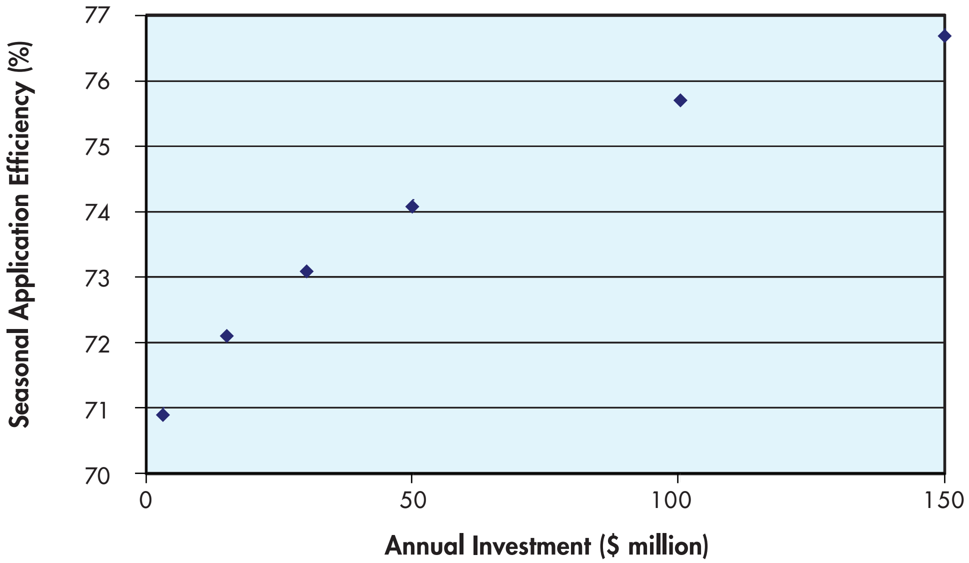
Education and Motivation

Improving agricultural water use efficiency depends on disseminating information on the use, costs, benefits, and impacts of technologies and on providing incentives for implementation. Existing evidence, although limited, indicates a strong response to financial incentives.

Dry-Year Considerations

In dry years, California's water supply is inadequate to meet its current level of use, and agriculture is often called upon to implement extraordinary water use efficiency or even land fallowing. Standard water use efficiency approaches to meet water

Figure 3-2 Statewide average on-farm seasonal application efficiency[1] at various levels of investment.



[1] Seasonal Application Efficiency is defined here as the evapotranspiration (ET) of applied irrigation water divided by the applied irrigation water.

CALFED studies show increasing statewide average seasonal application efficiency for additional annual investments in agricultural water use efficiency measures. This figure shows seasonal application efficiency increased from about 71% to 77% as annual investments were increased from zero to $150 million.

needs during dry years should to be reviewed and adopted. New approaches should be explored such as alfalfa summer dry-down and regulated deficit irrigation to save water.

Recommendations to Achieve More Agricultural Water Use Efficiency

The following recommendations can help facilitate more agricultural water use efficiency:

1. The State should identify and establish priorities for grant programs and other incentives as has been done by the CALFED Program for its solution area. This should include a process for quantifying and verifying intended benefits of projects receiving State loans and grants.
2. The State should fund technical and planning assistance to improve water use efficiency including local efforts to implement efficient water management practices and meet CALFED water use efficiency goals:
    - Provide technical and financial assistance to the Agricultural Water Management Council for implementation,monitoring, and reporting of all cost-effective efficient water management practices
    - Cooperate with the agricultural community to fund research, development, demonstration, monitoring and evaluation projects that improve agricultural water use efficiency
    - Support programs that encourage the development of new cost-effective water savings technologies and practices and evaluate cost-effectiveness of practices
    - Develop methods to quantify water savings and costs associated with hardware upgrade, water management, and evapotranspiration reduction projects identified in this strategy.
3. The Agricultural Water Management Council should continue to incorporate CALFED Quantifiable Objectives within the agricultural water management planning and implementation process, where applicable.
4. State loans and grants should provide ample opportunities for small water suppliers and economically disadvantaged communities, tribes and community-based organizations to benefit from technical assistance, planning activities, and incentive programs based on environmental justice policies.

5. The Agricultural Water Management Council should continue to encourage more water suppliers to sign the Memorandum of Understanding to broaden its support base. The Council should seek the support of the State and local agencies for full implementation of efficient water management practices by signatories and encourage the addition of new efficient practices as benefits are identified.
6. Expand CIMIS, mobile laboratory services, and other training and education programs to improve distribution uniformity, irrigation scheduling, and on-farm irrigation efficiency.
7. The State should provide additional funding for long-term ET reduction (regulated deficit irrigation, mulch, alfalfa dry down, etc.) demonstration and research plots and fund other promising programs to reduce evapotranspiration. Based on the long-term ET reduction studies and research, DWR should develop informational guidelines that define the crop water consumption reduction practices, identify how they can be implemented for each crop, and estimate the potential crop benefits and impacts, water savings, and costs for growers and water suppliers.
8. Encourage billing by volume of water-delivered rate structures that improve water use efficiency.
9. Collect, manage and disseminate statewide data on the cropped area under various irrigation methods, amount of water applied, crop water use, and the benefits and costs of water use efficiency measures. Develop statewide guidance to assist regions and water suppliers to collect the type of data needed in a form usable for future Water Plan Updates. DWR should work with the AWMC to develop a database of information from the Water Management Plans on water use-related data for dissemination and use in the Water Plan Update. DWR should work with CBDA to implement the recommendations of the Independent Panel on the Appropriate Measurement of Agricultural Water Use.
10. Develop community educational and motivational strategies for conservation activities to foster water use efficiency, with the participation of the agricultural and water industries and environmental interests. Develop partnerships with State, federal, UC Cooperative Extension Service, farm advisors, irrigation specialists, and State educational and research institutions to provide educational, informational, and training opportunities to growers, water supplier staff, and others on variety of water and irrigation management practices, operations, and maintenance.
11. The State should explore and identify innovative technologies and techniques to improve water use efficiency and develop new water efficiency measures based on the new information. Consider fast-track pilot projects, demonstrations, and model programs exploring state-of-the-art water saving technologies and procedures, and publicize the results widely. Foster closer partnership among growers, water suppliers, irrigation professionals, and manufacturers who play an important role in research, development, manufacturing, distribution, and dissemination of new and innovative irrigation technologies and management practices.

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Chapter 4 Conjunctive Management and Groundwater Storage

Conjunctive management allows surface water and groundwater to be managed in an efficient manner by taking advantage of the ability of surface storage to capture and temporarily store storm water and the ability of aquifers to serve as long-term storage. (DWR photo)

Chapter 4 *Conjunctive Management and Groundwater Storage*

Conjunctive management is the coordinated operation of surface water storage and use, groundwater storage and use, and conveyance facilities to meet water management objectives. Although surface water and groundwater are sometimes considered to be separate resources, they are connected by the hydrologic cycle. Conjunctive management allows surface water and groundwater to be managed in an efficient manner by taking advantage of the ability of surface storage to capture and temporarily store storm water and the ability of aquifers to serve as long-term storage.

There are three primary components to a conjunctive management project when the primary objective is to increase average water deliveries. The first is to recharge groundwater when surface water is available to increase groundwater storage (see Box 4-1). In some areas this is accomplished by reducing groundwater use and substituting it with surface water, allowing natural recharge to increase groundwater storage (also called in-lieu recharge). The second component is to switch to groundwater use in dry years when surface water is scarce. The third component is to have an ongoing monitoring program to evaluate and allow water managers to respond to changes in groundwater, surface water, or environmental conditions that could violate management objectives or impact other water users. Together these components make up a conjunctive management project. Conjunctive management projects may have other objectives in place of or in addition to improving average water deliveries. These other objectives may include improving water quality, reducing salt water intrusion, and reducing groundwater overdraft.

Other topics in the Water Plan that are related to conjunctive management include the strategies on Groundwater Remediation / Aquifer Remediation, Recharge Areas Protection, Water Transfers, and System Reoperation.

Conjunctive Management in California

Conjunctive management has been practiced in California to varying degrees since the Spanish mission era. The first known artificial recharge of groundwater in California occurred in Southern California during the late 1800s and is now used as a management tool in many areas. Two examples illustrate the types of conjunctive management under way on a regional and local scale. In Southern California, including Kern County, conjunctive management has increased average-year water deliveries by more than 2 million acre-feet (AGWA, 2000). Over a period of years, artificial recharge in these areas has increased the water now in groundwater storage by about 7 million acre-feet.

Box 4-1 Groundwater Recharge

Groundwater recharge is the movement of surface water from the land surface, through the topsoil and subsurface, and into de-watered aquifer space. Recharge occurs naturally from precipitation falling on the land surface, from water stored in lakes, and from creeks and rivers carrying storm runoff. Recharge also occurs when water is placed into constructed recharge ponds (also called spreading basins), when water is injected into the subsurface by wells, and when water is released into creeks and rivers beyond what occurs from the natural hydrology (for example, by releases of imported water). These later examples of recharge are often called artificial, intentional, managed or induced recharge. Significant amounts of recharge can also occur either intentionally or incidentally from applied irrigation water and from water placed into unlined conveyance facilities.

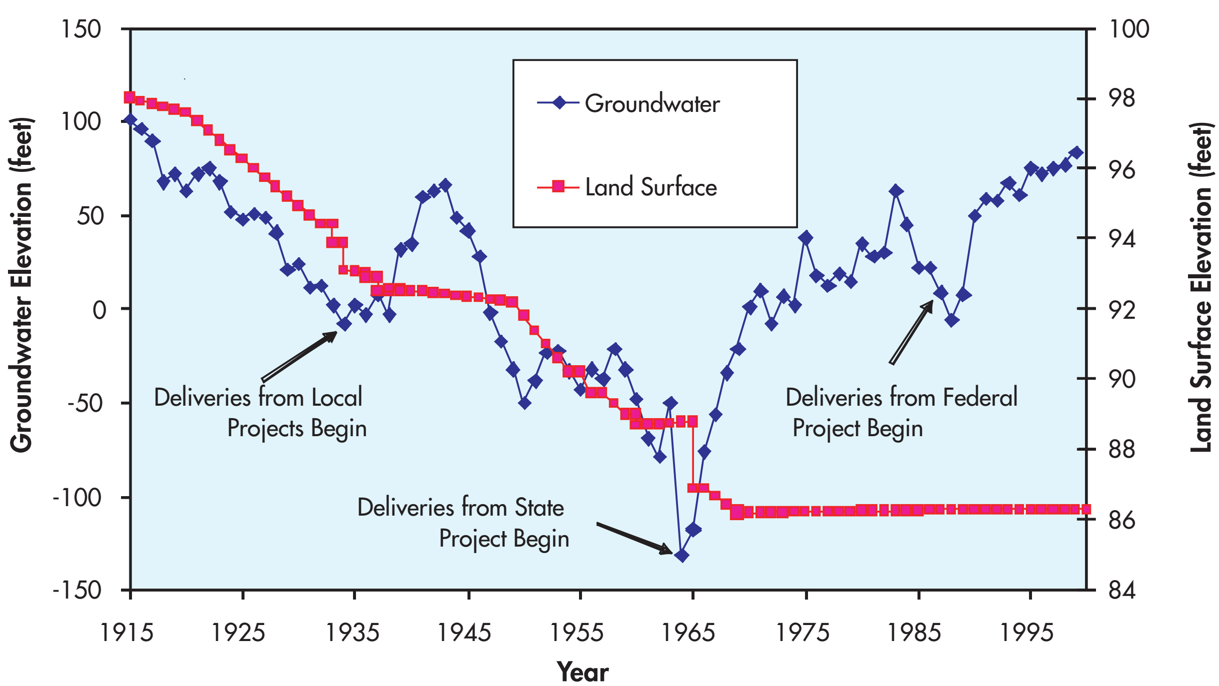
Santa Clara Valley Water District releases local supplies and imported water into more than 20 local creeks for artificial instream recharge and into more than 70 recharge ponds with an average annual recharge capacity of 138,000 acre-feet. Conjunctive management has virtually stopped land subsidence caused by heavy groundwater use and has allowed groundwater levels to recover to those of the early 1900s (see Figure 4-1).

There is no comprehensive statewide data on the planning and implementation of conjunctive management at the local agency level, but DWR's Conjunctive Water Management Program provides an indication of the types and magnitude of projects that water agencies are pursuing. In fiscal years 2001 and 2002 the program awarded more than $130 million in grants and loans to leverage local and regional investment in projects throughout California with total costs of about $550 million (see Figure 4-2).

Potential Benefits from Conjunctive Management

Conjunctive management is used to improve water supply reliability, to reduce groundwater overdraft and land subsidence, to protect water quality, and to improve environmental conditions. Conservative estimates of additional implementation of conjunctive management indicate the potential to increase average annual water deliveries throughout the state by 500,000 acre-feet with 9 million acre-feet of "new" groundwater storage[1]. New storage includes both reoperation of existing groundwater storage and recharging water into de-watered aquifer space. More aggressive estimates from screening level studies indicate the potential to increase average annual water deliveries by 2 million acre-feet with about 20 million acre-feet of new storage. The more aggressive estimates are based on assumptions that require major reoperation of existing surface water reservoirs and

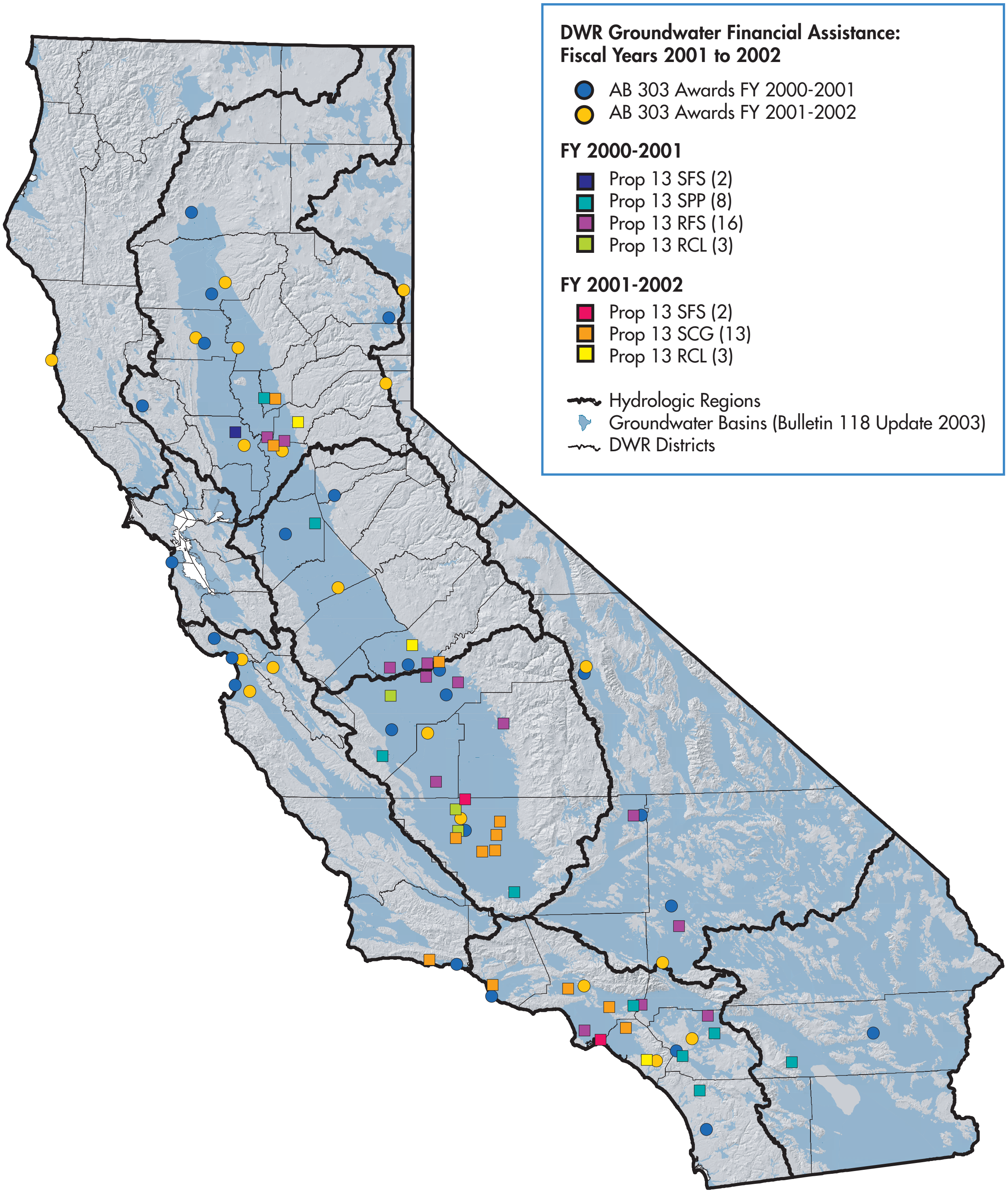
Figure 4-1 Relationship between groundwater elevations and land subsidence in Santa Clara County



Conjunctive management in Santa Clara County has virtually stopped land subsidence caused by heavy groundwater use, allowing groundwater to recover to early 1900s levels. Santa Clara Valley Water District releases local supplies and imported water into creeks for artificial instream recharge and into recharge ponds.

[1] Information in this section was derived from five sources: 1) Proposition 13 Groundwater Storage Applications to DWR for fiscal year 2001-2002, 2) A 2000 report by the Association of Groundwater Agencies entitled, "Groundwater and Surface Water in Southern California", 3) A 1998 report by the Natural Heritage Institute entitled, "Feasibility Study of a Maximal Program of Groundwater Banking", 4) A 2002 report by the Natural Heritage Institute entitled, "Estimating the Potential for In-Lieu Conjunctive Management in the Central Valley", 5) A 2002 report by the U.S. Army Corps of Engineers report entitled, "Conjunctive Use for Flood Protection".

Figure 4-2 Department of Water Resources, Division of Planning and Local Assistance groundwater grant and loan programs: AB303 and Proposition 13, FY's 2001-2002



In fiscal years 2001 and 2002, DWR's Conjunctive Water Management Program awarded more than $130 million in grants and loans to leverage local and regional investment in projects throughout California with total costs of about $550 million.

groundwater storage to achieve the benefits and do not fully consider the conveyance capacity constraints for exports from the Delta and other conveyance facilities.

The potential benefits from additional conjunctive management are highly dependent on adequate water quality and the ability to capture, convey, and recharge surface water. The above estimates are based on increases in local water deliveries from individual projects with project specific sources of recharge supply and do not necessarily reflect a statewide increase in supply reliability. An increase in statewide supply reliability only occurs when the individual projects use water that would otherwise not be used by other water users or that is not needed for regulatory requirements such as water quality, fish and wildlife, and navigation. Expanding existing or developing new storage or conveyance infrastructure can increase the flexibility and ability to conduct conjunctive management projects. It is also possible to reoperate the existing system and to improve the underlying operational conditions to overcome these constraints.

In addition to water supply benefits, conjunctive management can provide environmental benefits when recharge basins are designed to be compatible with wildlife habitat, such as using natural floodplains and wetlands as recharge areas. Re-operation of surface water storage and using the water conjunctively with groundwater can avoid impacts to aquatic species by allowing better management of instream flow and water quality conditions.

Potential Costs of Conjunctive Management

Grant applications from DWR's fiscal year 2001-2002 Conjunctive Water Management Program show project costs ranging from $10 to $600 per acre-foot of increase in average annual delivery. The wide range of costs is due to many factors including project complexity, regional differences in construction and land costs, availability and quality of recharge supply, availability of infrastructure to capture, convey, recharge, and extract water, intended use of water, and treatment require-

Box 4-2 Conjunctive Management Case Example: Orange County Groundwater Replenishment System

The Groundwater Replenishment (GWR) System is a groundwater management and water supply project jointly sponsored by the Orange County Water District (OCWD) and Orange County Sanitation District (OCSD). The project will take highly treated urban wastewater and treat it to beyond drinking water standards using advanced membrane purification technology. The water will be used to expand an existing underground seawater intrusion barrier by injecting the water into the groundwater basin along the coast. Extraction wells throughout the basin will draw potable water for municipal and industrial uses.

The GWR System will provide many benefits to Orange County and California, including:

- Supplements existing water supplies by providing a new, reliable, high-quality source of water to recharge the Orange County Groundwater Basin and protect the basin from further degradation because of seawater intrusion.
- Reduces the amount of treated wastewater released into the ocean and delays the need for another ocean outfall.
- Decreases Orange County's reliance on imported water from Northern California and the Colorado River.
- Helps drought-proof Orange County using a locally-controlled project.
- Reduces mineral build up in Orange County's groundwater by providing a new source of ultra-pure water to blend with other sources, including imported water.
- Uses about half the energy of imported water supplies.

Implementation of the GWR System will be phased. The schedule calls for Phase 1 of the proposed project to produce up to 72,000 acre-feet per year of recycled water for groundwater recharge to begin operation in 2007. The total cost of the project is estimated to be $453 million. The unit cost of the supply is $516 per acre-foot.

ments. In general, urban uses can support higher project costs than agricultural uses. The average project cost of all applications received by DWR is $110 per acre-foot of increase in average annual delivery. This average unit cost translates to statewide implementation costs of approximately $1.5 billion for the conservative level of implementation and $5 billion for the aggressive implementation[2].

Major Issues Facing Additional Conjunctive Management

Lack of Data

There is rarely a complete regional network to monitor groundwater levels, water quality, land subsidence, or the interaction of groundwater with surface water and the environment. Data is needed to evaluate conditions and trends laterally over an area, vertically at different depths, and over time. Also, there is often a reluctance of individuals who own groundwater monitoring or supply wells to provide information or allow access to collect additional information. The result is that decisions are often made with only approximate knowledge of the system. This uncertainty can make any change in groundwater use controversial. Additional investment in a monitoring network and data collection can help reduce this uncertainty, but must be done in accordance with a groundwater management plan that is acceptable to stakeholders in the basin.

Infrastructure and Operational Constraints

Physical capacities of existing storage and conveyance facilities are often not large enough to capture surface water when it is available in wet years. Operational constraints may also limit the ability to use the full physical capacity of facilities. For example, permitted export capacity and efforts to protect fisheries and water quality in the Delta often limit the ability to move water to groundwater banks south of the Delta. Facilities that are operated for both temporary storage of flood water and groundwater recharge require more frequent maintenance to clean out excessive sediment often present in flood water.

Surface Water and Groundwater Management

In California, water management practices and the water rights system treat surface water and groundwater as two unconnected resources. In reality, there is often a high degree of hydrologic connection between the two. Under predevelopment conditions many streams received dry weather base flow from groundwater storage, and streams provided wet weather recharge to groundwater storage. Water quality and the environment can also be influenced by the interaction between surface water and groundwater. Failure to understand these connections can lead to unintended impacts. For example, studies by the University of California, Davis, indicate that long term groundwater pumping in Sacramento County has reduced or eliminated dry season base flow in sections of the Cosumnes River with potential impacts to riparian habitat and anadromous fish.

In California, authority is separated among local, State and federal agencies for managing different aspects of groundwater and surface water resources. Several examples highlight this issue: 1) SWRCB regulates surface water rights dating from 1914, but not rights dating before 1914; 2) SWRCB also regulates groundwater quality, but not the rights to use groundwater; 3) County groundwater ordinances and local agency groundwater management plans often only apply to a portion of the groundwater basin, and those with overlapping boundaries of responsibility do not necessarily have consistent management objectives; and 4) Except in adjudicated basins, individuals have few restrictions on how much groundwater they can use, provided the water is put to beneficial use on the overlying property. Failure to integrate water management across jurisdictions makes it difficult to manage water for multiple benefits and provide for sustainable use including the ability to identify and protect or mitigate potential impacts to third parties, ensure protection of legal rights of water users, establish rights to use vacant aquifer space and banked water, protect the environment, recognize and protect groundwater recharge and discharge areas, and protect public trust resources. The Protecting Recharge Areas and Urban Runoff Management strategies describe how land use planning can affect groundwater recharge and groundwater quality.

Water Quality

Groundwater quality can be degraded by naturally occurring or human introduced chemical constituents, low quality recharge water, or chemical reactions caused by mixing water of differing qualities. Protection of human health, the environment, and groundwater quality are all concerns for programs that recharge urban runoff or reclaimed/recycled water. The intended end use of the water can also influence the implementation of conjunctive management projects. For example, agriculture can generally use water of lower quality than needed for urban use, but certain crops can be sensitive to some constituents like boron.

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[2] Cost estimates are extrapolated from Proposition 13 Groundwater Storage Applications to DWR for fiscal year 2001-2002. Cost estimates assume that the supply benefit is not restricted by Delta export constraints or conveyance capacity.

New and changing water quality standards and emerging contaminants add uncertainty to implementing conjunctive management projects. A water source may, at the time it is used for recharge, meet all drinking water quality standards. Over time, however, detection capabilities improve and new or changed water quality standards become applicable. As a result, contaminants that were not previously identified or detected may become future water quality problems creating potential liability uncertainties. In some cases, conjunctive management activities may need to be coordinated with groundwater clean up activities to achieve multiple benefits to both water supply and groundwater quality.

Environmental Concerns

Environmental concerns related to conjunctive management projects include potential impacts on habitat, water quality, and wildlife caused by shifting or increasing patterns of groundwater and surface water use. For example, floodwaters are typically considered "available" for recharge. However, flood flows serve an important function in the ecosystem. Removing or reducing these peak flows can negatively impact the ecosystem. A key challenge is to balance the instream flow and other environmental needs with the water supply aspects of conjunctive management projects. There may also be impacts from construction and operation of groundwater recharge basins and new conveyance facilities.

Funding

There is generally limited funding to develop the infrastructure and monitoring capability for conjunctive management projects. This includes funding to develop and implement groundwater management plans, to study and construct conjunctive management projects, and to track, both statewide and regionally, changes in groundwater levels, groundwater flows, groundwater quality (including the location/spreading of contaminant plumes), land subsidence, changes in surface water flow, surface water quality, and the interaction and interrelated nature of surface water and groundwater.

Recommendations to Help Promote Additional Conjunctive Management

1. Local water management agencies should coordinate with other agencies that are involved in activities that might affect long term sustainability of water supply and water quality within the basin or adjacent to the basin. Such regional coordination will take different forms in each area because of dissimilar political, legal, institutional, technical, and economic constraints and opportunities, but will likely include agencies with authority over managing groundwater and surface water quantity and quality, land use planning, human health, and environmental protection. Regional groundwater management plans should be developed with assistance from an advisory committee of stakeholders to help guide the development, educational outreach, and implementation of the plans.
2. Continue funding for local groundwater monitoring and management activities and feasibility studies that enhance the coordinated use of groundwater and surface water. Additional monitoring and analysis is needed to track, both statewide and regionally, changes in groundwater levels, groundwater flows, groundwater quality (including the location/spreading of contaminant plumes), land subsidence, changes in surface water flow, surface water quality, and the interaction and interrelated nature of surface water and groundwater. There is a need to develop comprehensive data and data management systems to track existing, proposed, and potential conjunctive management projects throughout the state and identify and evaluate regional and statewide implementation constraints including availability of water to recharge, ability to convey water from source to destination, water quality issues, environmental issues, and costs and benefits.
3. Give priority for funding and technical assistance to conjunctive management projects that are conducted in accordance with a groundwater management plan, increase water supplies, and have other benefits including the sustainable use of groundwater, maintaining or improving water quality, and enhancing the environment. Additional preference should be given for projects conducted in accordance with a regional groundwater management plan. In addition, allow funding for projects that make use of wet season/dry season supply variability, not just wet-year/dry-year variability.
4. Assess groundwater management throughout the state to provide an understanding of how local agencies are implementing actions to use and protect groundwater, an understanding of which actions are working at the local level and which are not working, and how State programs can be improved to help agencies prepare effective groundwater management plans.
5. Improve coordination and cooperation among local, State, and federal agencies with differing responsibilities for groundwater and surface water management and monitoring to facilitate conjunctive management, to ensure efficient

use of resources, to provide timely regulatory approvals, to prevent conflicting rules or guidelines, and to promote easy access to information by the public.

6. Encourage local groundwater management authorities to manage the use of vacant aquifer space for artificial recharge and to develop multi-benefit projects that generate source water for groundwater storage by capturing water that would otherwise not be used by other water users or the environment. For example, through reservoir reoperation, water recycling and reuse, and water conservation.
7. Work with wildlife agencies to streamline the environmental permitting process for the development of conjunctive management facilities, like recharge basins, when they are designed with pre-defined benefits or mitigation to wildlife and wildlife habitat.

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Chapter 5 Conveyance

Conveyance infrastructure includes natural watercourses as well as constructed facilities. An overall objective is to balance the operation and maintenance of conveyances to meet the needs of all sectors. (DWR photo)

Chapter 5 *Conveyance*

Conveyance provides for the movement of water. Specific objectives of natural and managed water conveyance activities include flood management, consumptive and non-consumptive environmental uses, water quality improvement, recreation, operational flexibility, and urban and agricultural water deliveries. Conveyance infrastructure includes natural watercourses as well as constructed facilities like canals, pipelines and related structures, including pumping plants, diversion structures, distribution systems, and fish screens. Groundwater aquifers are also used to convey water. Conveyance facilities range in size from small local end-user distribution systems to the large systems that deliver water to, or drain, areas as large as multiple hydrologic regions. Common water management objectives and evaluations do not consistently show preference for either regional or interregional options. Determinations must be made at the project level.

Conveyance in California

In general, conveyance facilities are used to move water from a source to where it is needed. An extensive system of conveyance facilities moves water with the use of its natural and constructed waterways. At the local level, water is distributed from locally developed sources to the end users. Since the state's ecosystem depends on water flow and quality in creeks, streams and rivers, an overall objective is to balance the operation and maintenance of these conveyances to meet the needs of all sectors.

The two longest conveyance projects in California are the State Water Project (SWP) and the Central Valley Project (CVP). Both the SWP and the CVP use natural rivers and constructed conveyances to deliver water from storage reservoirs in Northern California to a broad array of agricultural water agencies in Northern California and the San Joaquin Valley, as well as urban water agencies in the Sacramento Valley, San Francisco Bay Area, Central Coast, and urban Southern California. Levees along major rivers and levees in the Delta serve to convey flood water, but also convey water for water supply. The network of Delta levees and the hundreds of miles of interconnected channels convey water for in-Delta use and to the south of the Delta pumping facilities. Without the Delta levees, the Delta would be much saltier and unusable for water supply as we use it today.

A number of other interregional conveyances have been developed by local agencies. For example, East Bay Municipal Utility District and the San Francisco Public Utilities Commission have developed major conveyance systems that transport water from Sierra Nevada rivers directly to their service areas. The Los Angeles Department of Water and Power developed the Los Angeles Aqueduct to convey water from the Owens Valley to Los Angeles. A major source of water in Southern California continues to be diversion and distribution of Colorado River water via the All American Canal serving the Imperial Irrigation District, the Coachella Canal serving the Coachella Valley and the Colorado River Aqueduct delivering water to urban Southern California. Each of these conveyance systems is a major contributor to each region's water supplies and overall water supply reliability.

The existing network of interregional conveyance systems would not be capable of producing benefits if not for the ability of local water agencies to use conveyance to distribute imported, or locally produced, water to the end users, such as treated drinking water to residential or industrial users or irrigation water to agricultural users. In fact, conveyance is necessary in order for benefits to occur with virtually every other facet of local water management, such as desalination, recycling, use efficiency, and storage projects.

Other conveyance activities include environmental and recreation-related conveyance activities that can either be intentional or incidental to agricultural and urban water management activities. This could involve beneficiaries such as fish habitat (temperature, flow or quality improvements), riparian vegetation, or rafting and other recreational activities.

One current planning process that seeks to enhance conveyance connectivity at the regional level is the CALFED Bay Area Water Quality and Supply Reliability Program. This program is examining conveyance projects as well as other water management tools such as storage, recycling, and desalination in the Bay Area region to improve the area's drinking water quality and supply reliability. Existing regional, multiagency conveyance projects in the Bay Area already include the Hetch Hetchy Aqueduct, South Bay Aqueduct and emergency interconnects between various agencies. The program examines the effectiveness of additional regional conveyance projects that maximize operational efficiency and flexibility[1].

A major conveyance planning effort is the CALFED Conveyance Program which is expected to result in additional water supplies for the state beginning in 2006 (see Box 5-1). A summary of the water supply improvements of these project actions is provided in California Bay-Delta Authority Conveyance Program Plan for Years 5-8, as well as other documents.

Modeling studies indicate that the Delta Mendota Canal-California Aqueduct Intertie project which involves the construction of a 400 cfs interconnection between the Central Valley Project and the State Water Project south of Tracy will enable the CVP to deliver a long-term average of 35,000 acre-feet of additional water to its service area beginning in 2006. Currently, the amount, timing, and location of water deliveries from the DMC are limited by apparent canal subsidence, siltation, the facility design, and other factors. This Intertie will enable the CVP to use available capacity in the SWP's California Aqueduct. These results are expected to be reported in U.S. Bureau of Reclamation's Administrative Draft Environmental Assessment/Initial Study report on its water supply studies.

Box 5-1 CALFED Conveyance

Under the CALFED Conveyance Program, the CALFED Record of Decision calls out specific through-Delta conveyance actions that are to be studied for technical feasibility or directly implemented including:

- Increase SWP permitted pumping to 8,500 cubic feet per second
- Install permanent, operable gates in the south Delta
- Increase SWP permitted pumping to 10,300 cfs and construct Clifton Court Forebay fish screens
- Construct Tracy Fish Test Facility
- Implement Lower San Joaquin River Floodways Improvements and Ecosystem Restoration Project
- Evaluate improved operational procedures for the Delta Cross Channel and simultaneously evaluate a screened through-Delta facility on the Sacramento River up to 4,000 cfs
- Implement North Delta Flood Control and Ecosystem Restoration Improvements Program
- Consider the need for conveyance interties between the SWP and CVP in the vicinity of Delta Mendota Canal Mile Post 7 and between Clifton Court Forebay and the Tracy Pumping Plant
- Continue the Temporary Barriers Project until permanent flow control structures are built
- Facilitate water quality exchanges and similar programs to make high quality Sierra Nevada water available to urban Southern California interests
- Assist in implementation of the Sacramento and San Joaquin Comprehensive Study to improve flood control and ecosystem restoration

[1] System flexibility is defined as the ability to adaptively operate, or optimize, multiple water management strategies by controlling the timing, flow rate, location or quality of available supplies.

Under the South Delta Improvements Program, the Department of Water Resources proposes to increase the permitted pumping limit of the SWP from 6,680 cubic feet per second to 8,500 cubic feet per second and install permanent operable gates at up to four locations in south Delta channels with accompanying dredging. The project will be approved in stages. The first stage will begin after the release of the SDIP Public Draft environmental impact report-environmental impact statement and will address the number, location, construction and operation of the gates and associated dredging. The second stage will address whether to increase the SWP pumping limit to 8,500 cubic feet per second and the conditions under which it would be implemented. The staged decision process is designed to incorporate scientific information on the causes for the recent decline in the populations of several Delta fish species. Water supply studies conducted by DWR indicate that the SDIP could increase average annual water deliveries of the SWP and CVP by up to 90,000 acre-feet and 100,000 acre-feet respectively. The details of the studies will be reported in a draft environmental impact report-environmental impact statement for the SDIP to be released in late summer 2005.

Contra Costa Water District expects water quality improvement projects on Veale and Byron tracts to reduce the impact of local agricultural drainage waters that are high in salinity, and can include elevated levels of organic carbon and bromide. These projects and resulting water quality improvements are expected to result in increased exports of 10,000 acre-feet beginning in 2008 and an additional 10,000 acre-feet beginning in 2009. These results are reported in CCWD's report on its projects.

Another example of the use of conveyance to provide system flexibility within a region is the Metropolitan Water District of Southern California's network of local conveyance facilities. In addition to numerous locally developed water management options, this region receives water from multiple importation projects — namely the SWP and Colorado River. Both the importation and local options operate with different and often dynamic complexities involving water quality, hydrologic variability, costs, timing, risk levels, geographical distribution and capacities. Therefore, significant water management benefits occur by integrating water operations — using conveyance facilities — to help optimize operations based on the complexities described above.

Benefits of Improving Conveyance

The main benefits of conveyance to the urban, agricultural and environmental water-use sectors are in maintaining or increasing water supply reliability, protecting water quality, augmenting current water supplies, and providing water system operational flexibility. For the environmental sector, benefits include in-stream flows, appropriate temperatures and water quality for aquatic and riparian habitat. It is important to recognize that, in some cases, improving water supply reliability through system flexibility is just as valuable as increasing overall supply. Indeed, conveyance capacity improvements can enhance reliability without augmenting supplies or reducing demand by increasing system operational flexibility. Other specific benefits are:

- Conveyance is necessary for many of the other resource management strategies. Conveyance is needed to move water in water transfers between sellers and buyers. In order for water to be developed by new groundwater or off-stream surface storage, diversion facilities must be capable of filling the storage. Also, facilities must then be in place to convey the storage releases to the users at the right times and flow rates.
- Conveyance improvements can provide the flexibility to divert and move water at times that are less harmful to fisheries.
- Conveyance can improve water quality by moving more water when water quality conditions are better or less impacted by the movement of water, or by moving more water to improve water quality (that is, decrease salinity in the Delta).
- Given the high-intensity, short duration characteristics of California's hydrology, improved conveyance capacities combined with adequate surface water or groundwater storage can enable diversions of more water during high flow, less competitive periods, and consequently reduce the pressure to divert water during low flow, highly competitive periods.

Other benefits of conveyance improvements generally include:

- Enhancement of flood control capability
- Increases in water use efficiency
- Protection of water quality
- Increases in resiliency to catastrophic events
- Reductions in operating costs
- Improvements to instream and riparian habitat

Potential Costs of Water Conveyance

Conveyance costs can be a significant portion of the costs in a water management system. The cost of water conveyance heavily depends on the local circumstances, how far and when the water needs to be conveyed and topography (for example, pumping vs. gravity flow). For example, it costs less to convey water from Oroville Dam to the Delta, all gravity flow, than to convey water from the Delta to the South Coast Hydrologic Region. Conveying water through the Delta and over the Tehachapi Mountains increases water costs due to the canals, pipelines and pumping plants that need to be provided and the operating and maintenance costs of these facilities. However, by providing additional conveyance capacity to move water during off-peak energy demand periods, when power costs are lower, operating costs can be reduced. CALFED estimates of Delta conveyance improvements which are most likely to be implemented in the next 10 years are expected to cost about $230 million to $260 million to construct. Other potential conveyance improvements that are currently being studied could cost an additional $1.6 billion to $2.1 billion over the next 10 years. However, until all alternatives for these facilities are fully evaluated, these costs are tentative.

Major Issues Facing Conveyance

Maintenance

It is essential, at a minimum, to maintain the current level of conveyance capacity for both natural and constructed facilities. This is likely to take on very significant importance over time due to aging water infrastructure, the increasingly higher costs of maintenance, and the increasing demands with increasing population. Substantial reinvestment will be required just to maintain the current level of benefits. While concerns are likely to focus on adequate financial resources to maintain conveyance infrastructure, there is the special case of diminishing conveyance capacity in natural watercourses. This is most critical from both a water conveyance and flood passage standpoint in the channels of the Delta. Diminishing conveyance capacity is also a problem for flood management facilities such as bypasses that over time fill with silt, debris and plant growth that reduce the effectiveness for passing flood waters. In addition, rivers and streams depend upon a watershed which is in good condition. Watersheds provide the critical functions of snowpack storage, runoff, water quality, and water filtration in groundwater. Therefore, watershed management activities (see Watershed Management narrative in this volume) will also require investment as part of the natural infrastructure of the state's water system.

Science

Water managers, planners and biologists continue to work to identify and understand the relationships between hydrodynamics, flow timing, fish timing and movement, water temperature, geomorphology, water quality, environmental responses, global climate change and other conveyance related considerations so they can optimally plan, develop, operate and maintain natural and constructed conveyance infrastructure. Various CALFED programs have been studying these factors and expect to develop plans to improve the operation of the state's conveyances with a balanced approach to meeting the needs of its people and the environment. These studies are most evident in the Delta where export demands must be met, flood control improvements are needed, water quality improvements are being sought, and Delta fisheries and their habitat must be protected.

Regulatory Compliance

New conveyance projects may need to address impacts under the application of various laws, regulatory processes and statutes such as Public Trust Doctrine, Area of Origin statutes, California Environmental Quality Act, National Environmental Protection Act, the Clean Water Act and the Endangered Species Acts.

Local and Regional Water Supply Reliability

Greater interconnections are needed to help improve water supply reliability, as evidenced by how California has responded during drought conditions. Each water system has its own level of water supply reliability, based largely on storage and conveyance systems, hydrology, and level of demand. Operational flexibility, particularly during emergency conditions is a primary benefit of greater interconnection of independent water systems.

CALFED Through-Delta Strategy

The CALFED objective for its conveyance program employs a through-Delta approach to conveyance. Delta conveyance capacity and operational restrictions have been identified as key limitations to improving the water supply reliability and water quality for in-Delta and water export users. The current lack of flexibility also limits the ability to take advantage of other water management strategies such as water transfers, including transfer of previously stored water, conjunctive management, groundwater storage, and north of Delta water use efficiency. A key challenge for the California Bay-Delta Authority is to implement a strategy that will provide the necessary flexibility to the system and be protective of water quality, Bay-Delta hydrodynamics, fisheries, and habitat.

Area of Origin Interest

Interregional movement of water is sometimes opposed by the source-water counties. In addition to struggling to augment local water supplies to meet growing demands, area of origin interests often feel that the downstream water users could or should be more committed to assisting in managing the natural infrastructure, such as watersheds, from which their imported water originates.

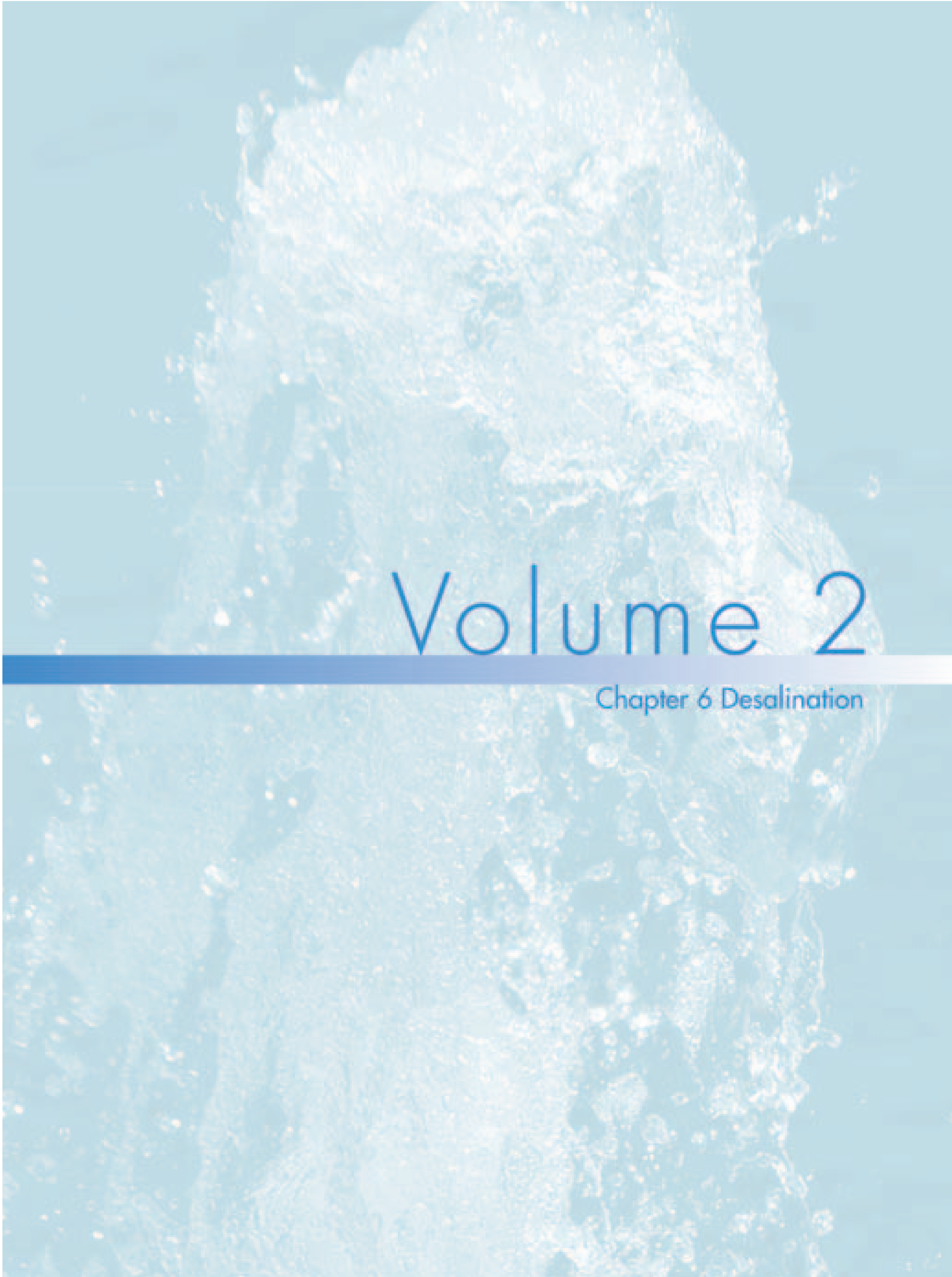
Recommendations

The following recommendations apply to state, federal and local water agencies:

1. Assure adequate resources to maintain existing constructed and natural conveyance facilities and capacity and condition. This may include development of a strategy to maintain channel capacity in areas of the Delta and in flood management facilities.
2. Promote development of more extensive interconnections among water resources systems such as, and in addition to, the SWP-CVP intertie or improved connectivity within the Bay Area Region. It is likely that leadership and funding on this will be at the local level.
3. Financially support the CALFED through-Delta conveyance improvements per CALFED ROD.
4. Financially support the lining of AAC and Coachella Canals to make water available to the South Coast Region.

Selected Reference

CALFED Record of Decision and Conveyance Program
www.calwater.ca.gov/.



Volume 2

Chapter 6 Desalination

Sweetwater Authority customers benefit from this desalination facility that treats brackish or saline groundwater. About 24 groundwater desalting plants operate in California and provide water for municipal purposes. The total capacity of these plants is approximately 79,000 acre-feet per year. (DWR photo)

Chapter 6 *Desalination*

Desalination is a water treatment process for the removal of salt from water for beneficial use. Desalination is used on brackish (low-salinity) water as well as seawater. In California, the principal method for desalination is reverse osmosis. This process can be used to remove salt as well as specific contaminants in water such as trihalomethane precursors, volatile organic carbons, nitrates and pathogens.

Only desalination for municipal purposes, that is, desalination used by public and private water agencies is considered in the following discussion. Desalination by industrial and commercial entities is not considered since those applications of desalting generally involve treating fresh water to a higher standard to meet a specific need. Desalination plant capacity for this paper is expressed in terms of the fresh or potable water capacity of the plant. Total costs are given in dollars per acre-foot of fresh potable water produced.

Current Desalination in California

Desalination began in California in 1965. The last decade has seen a rapid rise in installed capacity. This is primarily due to dramatic improvements in membrane technology and the increasing cost of conventional water supply development. Currently there are about 24 desalting plants operating in California that provide water for municipal purposes. The total capacity of these plants is approximately 79,000 acre-feet per year. These include 16 groundwater, one surface water, and seven seawater desalination plants.

In recognition of the increasing use of desalting in California, Assembly Bill 2717 (Hertzberg, Chapter 957, Statutes of 2002) called for DWR to establish a Desalination Task Force to look into:

- Potential opportunities for desalination of seawater and brackish water in California
- Impediments to using desalination technology
- What role, if any, the State should play in furthering the use of desalination

The Task Force completed its mission in October 2003 after six months of deliberations. DWR prepared recommendations (see Box 6-1) with significant input from the Task Force comprised of representatives from 27 organizations.

In November 2002, California voters passed Proposition 50, the Water Security, Clean Drinking Water, Coastal and Beach Protection Act of 2002. Chapter 6(a) of that proposition authorized $50 million in grants for brackish water and ocean water desalting projects. In the 2005 funding cycle, grants totaling $25 million have been awarded for research and development studies, pilot and demonstration projects, full-scale plant construction, and feasibility investigations.

Currently there are six new groundwater desalting plants and one plant expansion in the design and construction phase for a total of about 29,500 acre-feet per year in new capacity. There are no seawater desalting plants in the design and construction phases at this time.

Potential Benefits of Municipal Desalination in California

From San Francisco Bay to San Diego, there are numerous studies investigating the feasibility of desalting seawater.

Northern California – In the San Francisco Bay Area, agencies are jointly funding planning studies for a seawater desalination capacity of approximately 120,000 acre-feet per year. In Marin County, the Marin Municipal Water District is studying the feasibility of constructing a 15,000 acre-feet per year seawater plant. A pilot plant is now in operation to test pretreatment processes.

Central California – In the Monterey Bay area, the SWRCB has mandated a 10,730 acre-feet per year reduction in groundwater pumping from beneath the Carmel River. To replace this water and provide for water needs outside of the Monterey Peninsula area there are two competing proposals to construct regional seawater desalination facilities. Both of the proposals are for plants of about 20,000 acre-feet per year in capacity. The city of Marina is planning an expansion of their seawater desalting plant and the cities of Santa Cruz and Cambria are investigating the feasibility of using seawater desalting.

Southern California – In November 2001, the Metropolitan Water District of Southern California (MWD) issued a Request for Proposal (RFP) under its Seawater Desalination Program. The current objective is 150,000 acre-feet per year of sustained production. Through a competitive process, selected projects will be eligible for financial assistance up to $250 per acre-foot. Currently, five projects are under consideration that, if constructed, could produce about 127,000 acre-feet per year. As lead agency, the city of Huntington Beach is circulating an Environmental Impact Report for a 50,000 acre-feet per year seawater desalting facility. The San Diego County Water Authority is investigating the feasibility of a 50,000 acre-feet per year seawater desalting facility near the San Onofre power plant.

The benefits of desalination are:

- Increase in water supply
- Reclamation and beneficial use of waters of impaired quality
- Increased water supply reliability during drought periods
- Diversification of water supply sources
- Improved water quality
- Protection of public health

Box 6-1 Desalination Task Force Recommendations Summary (2003)

The Task Force recommendations are organized into three categories: General Recommendations, Energy and Environment Related Recommendations, and Planning and Permitting Related Recommendations.

General Recommendations:

1. Since each desalination project is unique and depends on project-specific conditions and considerations, each project should be evaluated on a case-by-case basis.
2. Include desalination, where economically and environmentally appropriate, as an element of a balanced water supply portfolio, which also includes conservation and water recycling to the maximum extent practicable.
3. Ensure equitable access to benefits from desalination projects and ensure desalination projects will not have disproportionate impacts particularly to low-income and/or ethnic communities.
4. The State should create mechanisms that allow the environmental benefits associated with transitioning dependence on existing water sources to desalinated water to be realized.
5. In conjunction with local governments, assess the availability of land and facilities for environmentally and economically acceptable seawater desalination.
6. Results from monitoring at desalination projects should be reported widely for the broadest public benefits. Encourage opportunities to share information on operational data. Create a database and repository for storing and disseminating information.
7. Create an Office of Desalination within the Department of Water Resources to advance the State's role in desalination.

Energy and Environment Related Recommendations:

8. Ensure seawater desalination projects are designed and operated to avoid, reduce or minimize impingement, entrainment, brine discharge and other environmental impacts. Regulators, in consultation with the public, should seek coordinated mechanisms to mitigate unavoidable environmental impacts.
9. Identify ways to improve water quality by mixing desalinated water with other water supplies.
10. Where feasible and appropriate, utilize wastewater outfalls for blending/discharging desalination brine/concentrate.

continued

The primary benefit of desalting is to increase California's water supply. Seawater desalting creates a new water supply by tapping the significant supply of feedwater from the Pacific Ocean.

Table 6-1 shows, as of 2005, the number and capacity of groundwater and seawater desalting plants in operation, design and construction, and planned or projected for construction. The projects in the planned and projected capacity are assumed to be operational by 2030. While not all of these are likely to be constructed, it is assumed that they, or an equivalent number, will be operational by 2030.

In addition to the above, there is additional new water supply possible from desalting oil field production water in the San Joaquin and Salinas valleys and brackish agricultural drainage water in the San Joaquin and Imperial valleys. These are not quantifiable at present.

Desalting wastewater increases the range of beneficial uses for which recycled municipal wastewater can be used. Of the 1,200,000 acre-feet per year (see the Recycled Municipal Water narrative) in reclaimed water projected for 2030, approximately 150,000 acre-feet per year will include desalting in the treatment process.

Desalting groundwater allows groundwater of impaired quality to be adequately treated for potable use. Approximately 170,000 acre-feet per year in capacity is currently planned or projected to be constructed. Groundwater desalting may or may not be a new water supply depending upon the water portfolio or balance in the area or region where it occurs. It is, however, providing water from a source that is not currently being used for beneficial purposes.

Potential Costs of Desalination

Recent technological advances in various desalination processes have significantly reduced the cost of desalinated water to levels that are comparable, and in some instances competitive, with other alternatives for acquiring new water supplies. Desalination technologies are becoming more efficient, less energy demanding and less expensive. Significant progress and innovation in membrane technologies such as reverse osmosis (RO) has helped reduce costs. The RO process has been proven to produce high quality drinking water throughout the world for decades.

The estimated capital cost to achieve 415,000 acre-feet per year in increased seawater desalting capacity is about $2 billion. Table 6-2 shows the range in total unit water cost

Box 6-1 continued from previous page

11. Compare reasonable estimates of benefits, costs and environmental impacts for desalination with those for other water supply alternatives realistically available to that area.
12. Recognizing the importance of power costs to the costs of desalination, consider strategies that will allow project sponsors to access non-retail power rates.
13. Clarify the applicability of non-retail energy pricing for desalination facilities.
14. Study the energy intensity and rates currently paid for energy used to provide water from various sources including desalination.
15. Study the potential for developing renewable energy systems in California, in conjunction with desalination implementation strategies.
16. Identify ways that desalination can be used in a manner that enhances, or protects the environment, public access, public health, view sheds, fish and wildlife habitat and recreation/tourism.

Planning and Permitting Related Recommendations:

17. To improve communication, cooperation, and consistency in permitting processes, encourage review processes for each desalination project to be coordinated among regulators and the public.
18. Evaluate all new water supply strategies including desalination based upon adopted community General Plans, Urban Water Management Plans, Local Coastal Plans, and other approved plans that integrate regional planning, growth and water supply/demand projections. Environmental reviews should ensure that growth related impacts of desalination projects are properly evaluated.

Table 6-1 Desalting in California for new water supply

	Plants in Operation		Plants in Design & Construction		Plants Planned or Projected	
Feedwater Source	No. of Plants	Annual Capacity	No. of Plants	Annual Capacity	No. of Plants	Annual Capacity
Groundwater	16	79,100	6	29,500	6	61,700
Seawater	7	1,500	1	300	13	415,100
Total	23	80,600	7	29,800	19	476,800
Cumulative			30	110,400	49	587,200

1. Capacity in Acre-feet per year. No. of Plants is the number of new plants.
2. Design & Construction – Construction underway or preparation of plans and specifications has begun for new plants or plant expansions.
3. Planned – Planning studies underway for new plants or plant expansions.
4. Projected – Projected new plants or plant expansions.
5. Sources: "Water Desalination Report", and Worldwide Desalting Plants Inventory series by International Desalination Association.

that can be expected from plants desalting groundwater (or brackish), wastewater, and seawater. These costs are based on the expected lifetime of the plant (20-30 years).

Major Issues in Desalination

Historically, the cost of desalting has been the major issue regarding desalting, with energy use a close second. As desalting costs have declined and the cost of traditional water supplies has increased, desalting is increasingly being considered. As a result, two additional issues have increased importance, environmental impacts and permitting (particularly for coastal plants).

Cost and Affordability – Desalination has historically been prohibitively expensive. The improvements in technology and the rising cost of conventional water supplies has made desalination competitive with importing water and recycled municipal wastewater in a number of cases. The cost will be influenced by the type of feedwater, the available concentrate disposal options, the proximity to distribution systems, and the availability and cost of power. The higher costs of desalting may, in some cases, be offset by the benefits of increased water supply reliability and/or the environmental benefits from substituting desalination for a water supply with higher environmental costs (e.g. Carmel River, Monterey Bay area).

Environmental Impact and Permitting – Brackish water desalination plants have fairly routine environmental and permitting requirements. Coastal desalination plants face much closer scrutiny. With a location within the coastal zone, and with the need for water intakes and outfalls, there are many reviewing agencies, organizations, and permitting requirements.

Seawater Intakes – Existing seawater intakes for power plant cooling are proposed as the source of supply for almost all of the currently proposed plants. In general, these existing intake systems have been shown to have fairly significant impacts on the coastal zone. A number of coastal power plants that use once-through cooling water from the ocean may cease operation or convert to a "dry" cooling system. In addition, some plants are not in continuous operation. These may limit the potential capacity of seawater desalting on the coast.

Concentrate Discharge – Desalination plants of any type produce a salt concentrate that must be discharged. The quantity and salinity of that discharge varies with the type of desalting plant and its operation. Brackish water plants in California discharge their concentrate to municipal wastewater treatment systems where they are treated and blended with effluent prior to discharge. For brackish water plants, this type of discharge is likely to continue. Inland desalting plants without a discharge to the ocean may be limited by the type of discharge options available. Seawater desalination produces a concentrate approximately twice as salty as seawater. In addition, residuals of other treatment chemicals may also be in the concentrate. The plants currently being planned are to utilize existing power plant outfall systems to take advantage of dilution and mixing prior to discharge. The availability of power plant cooling systems to dilute the concentrate prior to discharge to the ocean will also be affected by the future of coastal power plants as discussed in the prior section.

Energy Use – Desalination's primary operation cost is for power. A 50 mgd seawater plant (approximately 50,000 acre-feet per year assuming operating 90% of the time) would require about 33 MW of power. Forecasted seawater desali-

Table 6-2 Desalting total water costs[1]	
Type of Desalting Plant	**Total Water Cost - $ per Acre-Foot**
Groundwater	$250-500
Wastewater	$500-2,000
Seawater	$800-2,000

[1]Unit costs obtained from a variety of sources including agency reports, technical journals, and general periodicals, and are not based on a standard costing procedure.

nation of about 187,000 acre-feet per year would require about 123 MW of power. The reduction in unit energy use has been among the most dramatic improvements in recent years due to improvement in energy recovery systems.

Growth-inducing Impacts – The availability of water has been a substantial limitation on development in a number of locations, primarily coastal communities. Since desalination on the coast is now a much more affordable option in comparison to the past, the lack of water may no longer be as strong a constraint on coastal development.

Recommendation to Promote Desalination in California

DWR should lead the development of a consensus process, involving appropriate stakeholders, to identify criteria and prioritize the implementation of Task Force recommendations, given the expected expenditures, using existing and new funding sources (see Box 6-1, Desalination Task Force recommendations).

Selected References

Water Desalination Task Force (AB 2717 [Hertzberg, Chapter 957, Statues of 2002])

"Water Desalination - Findings and Recommendations", Department of Water Resources, October 2003

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"Seawater Desalination and the California Coastal Act", California Coastal Commission, March 2004.

"Seawater Desalination: Opportunities and Challenges", National Water Research Institute, March 2003.

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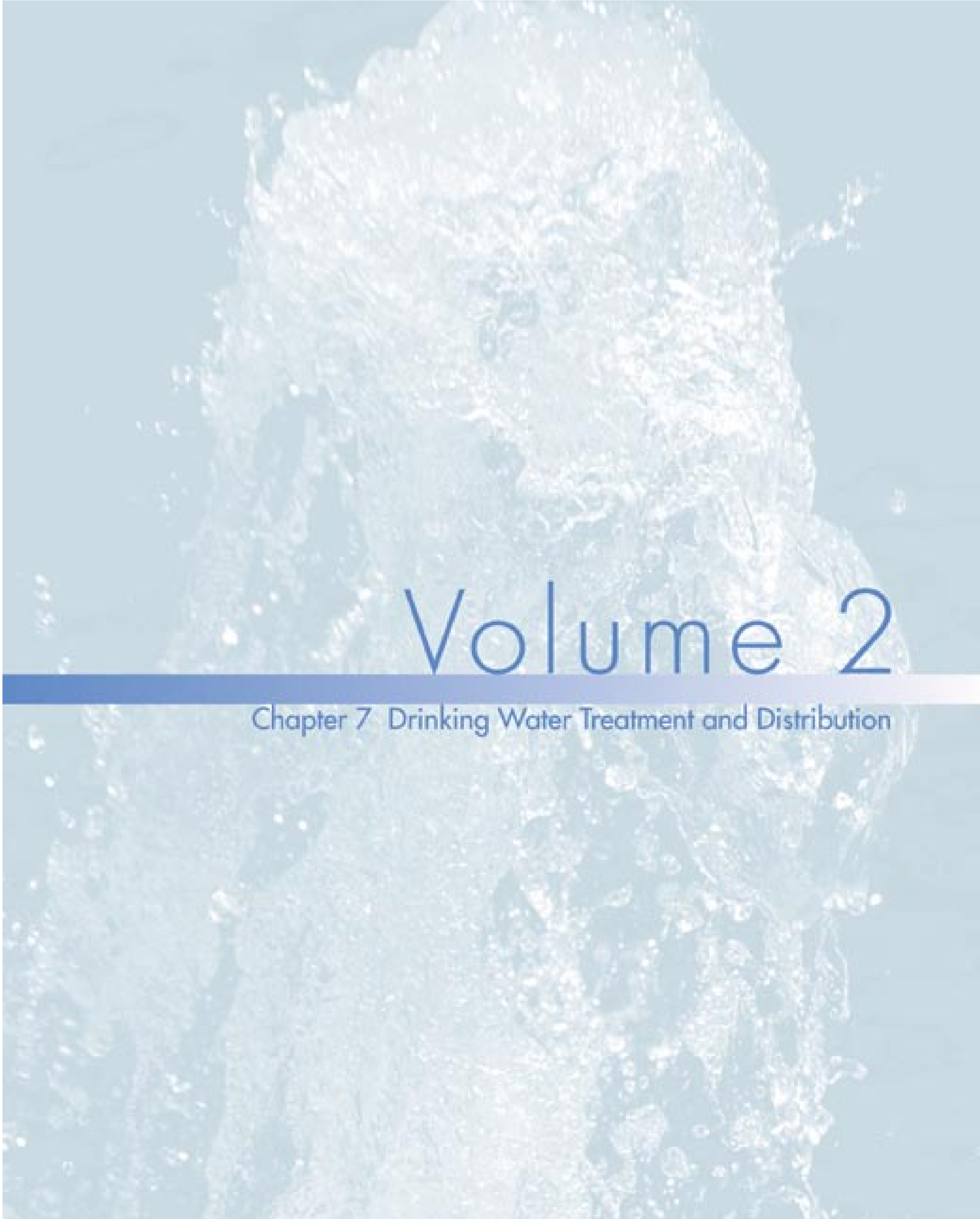

Volume 2

Chapter 7 Drinking Water Treatment and Distribution

Even after preventing pollution and matching water quality to use, drinking water supplies generally still require some level of treatment to achieve a potable level of water quality. The Bryte Bend Water Treatment Plant supplies drinking water to the City of West Sacramento. (City of West Sacramento photo)

Chapter 7 *Drinking Water Treatment and Distribution*

Drinking-water treatment includes physical, biological, and chemical processes to make water suitable for potable use. Distribution includes the storage, pumping, and pipe systems to protect and deliver the water to customers. Even after preventing pollution and matching water quality to water use (see preventing pollution and matching water quality to water use strategies), drinking water supplies will generally still require some of level of treatment to achieve a potable level of quality, which will then need to be maintained in a distribution system. Widespread treatment of drinking water, especially disinfection and fluoridation, was one of the great public health advancements of the 20th century.

Drinking Water Treatment and Distribution in California

The State of California has a role in ensuring the safety of the public water supply and the health of Californians who use it. State Department of Health Services regulations require all surface waters in California be filtered and disinfected, except for a small number that meet DHS's "filtration avoidance" criteria, like San Francisco's Hetch Hetchy water supply.[1] Basic surface water treatment consists of pretreatment (primarily sedimentation), filtration through sand and gravel followed by disinfection with chlorine. Many water suppliers use more advanced treatment such as granular activated carbon (GAC) for filtration and ozone and chloramination, a combination of chlorine and ammonia, for disinfection. Together, filtration and disinfection are the key parts of the traditional "multiple-barrier" approach to treating drinking water. This is consistent with an integrated, "source-to-tap" approach to water quality, which can be expanded upstream to include watersheds, and downstream, to include distribution systems.

In Southern California, the Los Angeles Department of Water and Power has disinfected Owens Valley water with ozone for the past 20 years. The Metropolitan Water District is upgrading to ozone disinfection at its five treatment plants, which use either Delta water exclusively, or a blend of Colorado River and Delta water. UV radiation is a promising advanced disinfection technology, but has yet to be implemented in a large-scale domestic water treatment plant in California. The integration of multiple disinfectants also shows promise in optimizing protection from microbiological contaminants in drinking water. Some smaller water treatment plants use membrane filtration, which produces relatively high quality water. The waterworks industry is exploring the feasibility of point-of-entry (POE) and point-of-use (POU) devices, which would treat only that water used for domestic purposes, and which could provide quicker and more cost-effective water quality improvements. Water systems that rely on groundwater disinfect well water only with chlorine, unless a specific contaminant is found.

Distribution system water quality is emerging as an important issue in the waterworks community, especially given recent heightened awareness of water supply security. Historically, treated water storage and associated distribution systems were designed to meet fire suppression flow requirements rather than water quality. Water in distribution systems can be contaminated by cross-connections with non-potable water, such as recycled water, open treated water distribution reservoirs, and water main repair and replacement. Lead, the by-products of corrosion, and regrowth of microorganisms can also contaminate water. Ironically, the implementation of ozone for disinfection, while effective in killing microbes, reducing objectionable tastes and odors, and generally forming fewer disinfection byproducts, can create conditions that can

[1] Please refer to Volume 1, Chapter 3, for the legal and regulatory framework for drinking water treatment and distribution.

encourage the growth of microorganisms in water distribution systems. Aging water systems — some well over 100 years old — in general are not being replaced or rehabilitated within their useful lives. Small rural water systems, that is, those serving fewer than 3,300 connections, face unique treatment and distribution challenges, because they lack the technical and financial ability to address water contamination. Such systems are often the most frequent violators of drinking water standards. And they often must cope with some of the most difficult water quality problems, such as arsenic and more traditional contaminants such as nitrate and coliform bacteria.

Potential Benefits

Improved water quality can directly improve the health of Californians, thereby improving the state's standard of living and reducing the burden and costs on the state's healthcare system. Many water contaminants potentially cause cancer, nervous system and organ damage, developmental impairments, and dysfunction of the reproductive and endocrine systems; others can cause short-term gastrointestinal illnesses, resulting in lost work and school days. If poor water quality causes a need for medical treatment by many uninsured Californians, the costs will be borne by state health programs, such as MediCal, which directly impacts the State budget. In addition, many consumers who choose to purchase relatively expensive bottled water or home treatment units could save more of their personal budgets if they instead used safe tap water.

The U.S. Environmental Protection Agency has proposed new regulations to reduce both the gastrointestinal and carcinogenic disease risks of drinking water. The agency estimates that the Long Term 2 Enhanced Surface Water Treatment Rule will prevent more than 1 million cases of cryptosporidiosis, a gastrointestinal ailment, and up to 140 premature deaths annually, providing $1.4 billion in benefits. EPA also estimates that the Stage 2 Disinfection Byproducts Rule will prevent up to 182 cases of bladder cancer per year, providing nearly $1 billion in benefits. USEPA also estimates that the combined costs of these two proposed regulations are less than $24 per year for most households.

Potential Costs

Advanced water treatment itself is about 1 percent of a customer's overall water bill. For example, the 40 million gallon-per-day North Bay Regional Water Treatment Plant, which serves Fairfield and Vacaville, treats a blend of Lake Berryessa and Delta water with GAC filtration and ozone. The operations and maintenance expenses of this plant costs $0.04 per 1,000 gallons, on a total metered charge of $3 per 1,000 gallons. Also, the Metropolitan Water District of Southern California estimates that the total cost of its upgrade to ozonation at its five treatment plants will cost about $50 per acre-foot, including operations and maintenance costs of $9-$12 per acre-foot (equal to $0.03 to $0.04 per 1,000 gallons). Nonetheless, despite the relatively low costs, economies of scale negatively affect small water systems that have a smaller rate base to spread both capital and O&M expenses.

As for infrastructure, the American Society of Civil Engineers (ASCE) recently gave a grade of "D" to drinking water infrastructure in its 2003 Progress Report for America's Infrastructure. EPA estimated in October 2002 that over the next 20 years, the nation would be short $535 billion for water and wastewater infrastructure. The drinking water estimate alone was $265 billion. EPA estimates California's drinking water infrastructure needs about $1 billion annually over the next 20 years.[2] EPA also predicted that per household costs to small water systems will be four times that of customers of large water systems — those serving more than 50,000 persons.

Major Issues

Access to Safe Drinking Water

Safe drinking water is fundamental to public health. A recent report, *Californians Without Safe Water,* found that more than 81,000 California households may rely upon an unsafe source of water. In lieu of a connection to a public water system, many of these households may be obtaining their drinking water from shallow wells, springs, or hauled-water supplies that are vulnerable to contamination. Moreover, many other households and schools, often in rural or low-income areas, are connected to small water systems that are less scrutinized by regulatory agencies. These small systems usually have limited funds and staffing to pursue improvements in drinking water quality, including the preparation of grant applications for funding assistance. Even for those households that are connected to a public water system, DHS reports that in 2001, more than 40,000 people got their water from public water systems that had repeated violations of the coliform bacteria drinking water standard, and that more than 700,000 people were served water in violation of surface water filtration and disinfection regulations. In

[2] Adjusted to January 2004 dollars, EPA's estimate for California is $17 billion to $21 billion.

addition, nearly 1 million Californians got water in 2001 from public water systems that had a "significant sanitary defect involving sewage."

Emerging Contaminants

New contaminants are often discovered and then regulated because of increased pollution, improved analytical abilities, and better understanding of health effects. In addition, the health effects of many known contaminants are re-evaluated — and re-regulated — in light of new information. For many emerging contaminants (for example, from personal care products and pharmaceuticals), there may not yet be treatment technologies available to remove them from drinking water. For such contaminants, only pollution prevention, or matching water quality to water use, will adequately address water quality. In fact, emerging contaminants may be created by treatment itself, for instance, when water utilities implement new methods or processes for disinfecting water. For some contaminants, treatment options, such as membranes, may be available, but they are relatively expensive.

Risk, Demographic Changes

There are increasing numbers and proportions of immunocompromised individuals, as well as children and elderly, who are more susceptible than the general population to the risks of waterborne disease and exposure to contaminants. At the same time, water agencies are responding to regulatory signals that require control of disinfection byproducts in treated surface water. Depending upon the treatment scheme employed, measures to reduce the probable long-term risks of cancer can be at odds with efforts to protect the public from known short-term risks from microorganisms.

Contaminant Interactions and Cumulative Effects

There is growing concern about the interactions and cumulative effects on human health of multiple contaminants in drinking water. Such effects are not addressed by current drinking water standards, which only regulate contaminants on an individual basis. Moreover, some contaminants, such as disinfection byproducts, present risks simultaneously through multiple exposure routes (e.g. ingestion, inhalation, or the skin). The CALFED Drinking Water Quality Program is attempting to address this concern via its "Equivalent Level of Public Health Protection" strategy, which looks comprehensively at the total concentration of contaminants in drinking water, and integrates pollution prevention, alternative water sources, facility re-operation, and advanced treatment to reduce contaminants.

Recreation

The State Department of Parks and Recreation forecasts an increasing demand for recreation on reservoirs, including drinking water reservoirs, such as Lake Perris in Southern California. An increase in reservoir contamination, especially microbiological from swimmers, water skiers or others whose bodies come in contact with the water, can correspondingly increase the need for treatment and degrade the quality of tap water produced from these lakes.

Public Distrust

Public opinion surveys consistently suggest that Californians, across all socio-economic groups distrust their tap water, often because of tap water taste, odor, or appearance. They choose instead to rely on home treatment devices and bottled water. Quite simply, improvements in water quality may not lead to improvements in public health if the public is not drinking the water. While some amount of bottled water use is related to convenience or lifestyle choices, the poor perception of tap water is a factor as well. However, the public may not have access to complete information about the relative safety of bottled and tap waters, and may be misplacing their trust in sales pitches for bottled water and home treatment devices.

Affordability

Even though water treatment is a relatively small portion of a customer's water bill, increased costs are a concern for many people. As costs increase, the relative burden on the household budgets of poor families will increase at rates greater than that of the general population. Moreover, the waterworks industry generally lacks lifeline rates for poor customers relative to other utilities, such as gas, electricity, and telephone. For those economically disadvantaged consumers who choose to purchase bottled water, money spent on that commodity may be better spent on other life necessities.

Recommendations to Improve Drinking Water Treatment and Distribution

1. All Californians should have access to safe drinking water. Thus, the State should assist in funding drinking water and wastewater infrastructure needs in areas—including on tribal lands—without piped domestic water and therefore not covered by the State and federal Safe Drinking Water Acts.
2. The State, local water agencies, and non-profit organizations should better educate the public about the actual and

perceived risks of tap water, bottled water, and water produced by home treatment units. State and local water agencies should specifically improve outreach to and communication with vulnerable populations that may indeed be at a higher actual level of risk of waterborne disease or other health effects from drinking water contaminants. Doctors and other healthcare professionals, in whom the public may place their trust, should be involved in this effort.

3. Communities should have useful access to, knowledge of, and engagement in, drinking-water quality monitoring and assessment. In addition, decision-making at all government levels should be transparent and involve affected communities, tribes, and general purpose local governments. Examples of vehicles for such access, knowledge, and engagement include citizen water quality monitoring programs, and water quality community advisory committees, at the local water system level.

4. The State should consider increasing the set-aside funding for capacity building within the Drinking Water State Revolving Fund to the maximum allowed by EPA for these purposes. Systems that serve large proportions or numbers of vulnerable populations, such as schools, should receive funding priority. The State should increase its formal partnerships with non-governmental organizations that are experienced in assisting small water systems in grant and loan applications in order to improve community access to information and funding, address the most pressing public health risks, and ensure an equitable distribution of grant and loan funds.

5. The State should implement guidelines for the design and operation of distribution systems to maintain system water quality. As a part of these guidelines, the State should ensure that public water systems are prepared for natural and man-made disasters, and are able to reliably maintain or quickly restore water quality in the aftermath of such disasters.

6. Water utilities must prevent possible cross-contamination of potable water from dual-plumbing of potable and recycled water distribution systems and other non-potable sources.

7. In response to continuing, legitimate concern from citizens, the State should monitor and resolve the potential health impacts of indirect potable reuse of recycled water.

8. The State Water Project and local agencies should only permit recreation on reservoirs that do not endanger the public health of those who drink the water from those reservoirs.

9. The State should coordinate its funding sources (e.g., the Drinking Water and Clean Water State Revolving Funds) in order to better address projects with multiple benefits—such as drinking water supplies threatened by contamination from septic systems. State water quality funding sources for small water systems should be closely coordinated with federal water quality monies, including funds available from the U.S. Department of Agriculture.

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Metropolitan Water District of Southern California

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ASCE 2003 Progress Report for America's Infrastructure

Volume 2

Chapter 8 Economic Incentives (Loans, Grants, and Water Pricing)

Economic incentives are financial assistance and pricing policies intended to influence water management. A Proposition 13 grant funded this water storage tank in Tranquillity, a farming community in the Central Valley. The multi-objective project replaced a failing elevated water storage tank constructed in 1920. With a capacity of 500,000 gallons, it provides water supply to area residences and agriculture. (DWR photo)

Chapter 8 *Economic Incentives (Loans, Grants, and Water Pricing)*

Economic incentives are financial assistance and pricing policies intended to influence water management. For example, economic incentives can influence amount of use, time of use, wastewater volume, and source of supply. Economic incentives include low-interest loans, grants, and water pricing rates. Free services, rebates, and the use of tax revenues to partially fund water services also have a direct effect on the prices paid by the water users. In general, higher costs to water users tend to reduce water use. Governmental financial assistance can provide incentives for resource plans by regional and local agencies. Also, government financial assistance can help water agencies make subsidies available to their water users for a specific purpose, (Box 8-1).

Economic Incentives in California

The most prevalent water rate policy is for water agencies to recover costs for such things as planning, operation, maintenance, capital, administrative, and some environmental costs. Water rates are also commonly used to contribute to water agency capital investment accounts for funding anticipated projects. Water rates could be used to recover external costs such as third-party costs. Other means available to recover costs include ad velorum taxes and revenues from bonds not repaid from water rates.

Because of existing policy, some agencies are not required to recover the full cost of development and maintenance. For example, Congress has not required the U.S. Bureau of Reclamation to recover all the costs of supplying water to agriculture. This is an example of a subsidy that was designed to achieve a social goal that affects water use and agricultural development in the West. Urban wastewater treatment also traditionally has not been required to recover the full cost of projects because of substantial federal grant funding through the Clean Water Act.

Other examples of economic incentives include:

- The California Bay-Delta Authority, the Department of Water Resources, and the State Water Resources Control Board administer low-cost loans and grants programs to encourage agricultural and urban water conservation, urban water recycling, agricultural and urban ground water storage, and conjunctive use projects.
- At the wholesale agency level, the Metropolitan Water District of Southern California has recently developed plans to expand its Local Resources Program, which provides a subsidy of up to $250 per acre-foot to its member agencies for water recycling, groundwater recovery, and seawater desalination. MWDSC's water rates structure includes a "water stewardship charge" to collect revenue to subsidize individual retail agency programs that benefit the region.
- Incentives can include rebate programs for low-flush toilet installation, water audits for residential landscapes and mobile lab services for increasing on-farm water use efficiency at no charge to customers, or other innovative programs.

Box 8-1 State-Managed Grants and Loans

Since 1984 Californians have approved six bonds propositions that provided $1 billion to fund local water supply and conservation programs (Propositions 25, 44, 82, 204, 13, and 50).

Water rates can take several forms. Water rate structures designed to recover costs can be fixed, uniform, or tiered (see Box 8-2). Both uniform and tiered rates can have a fixed component. Where water use is unmetered, fixed assessments might be necessary. For example, water rates can be based on connection size for urban users or acreage irrigated for agricultural users.

Most urban agencies in California are moving away from uniform rates and toward rate structures based on the amount of water used. Many urban agencies have already adopted tiered rate structures where the unit water charge increases as water use increases; the more units of water used, the higher the charge for each subsequent unit. Some tiered water rate structures may have higher seasonal rates. In 1999, of 326 California urban water purveyors surveyed, about 45 percent had tiered rates, 42 percent had uniform rates, 11 percent had flat or other type rates, and 2 percent had declining block rates[1]. Some agricultural agencies, particularly concerned with drainage water management, have adopted tiered rate structures. Most apartment building owners don't individually meter their tenants, removing the effect of volumetric pricing on the tenants' water use.

While most residential wastewater treatment is currently charged at a flat rate, commercial and industrial users are more likely to be charged by wastewater volume (and, in some cases, the types of constituents in their wastewater).

Potential Benefits from Economic Incentives

A major purpose of economic incentives is to reduce water demands. This may produce environmental or social benefits, or avoid or delay construction of new water supply projects. When water costs increase, customers have a choice to either pay the higher water bill or find ways to use less water, such as using a broom or blower to clean sidewalks instead of a hose. Residential and agricultural customers might purchase more efficient conservation technologies, such as installing a drip irrigation system, or they may forego some water use, including removing some of their residential landscaping or agricultural acreage from irrigation.

Economic incentives that produce more efficient water management practices can result in benefits or costs to the environment by changing water quality or the timing of diversions. Conversely, water rate policies that lower the cost of surface water during wet cycles can encourage storage in groundwater basins. Water quality improvements resulting from economic incentives can help farmers meet drainage water goals as well as lower treatment costs or provide health benefits to urban users in addition to benefiting the environment.

Marginal-cost pricing is one strategy to promote more efficient water use. With marginal-cost pricing, customer rates would reflect the full cost of the last, and probably the most expensive, source of supply. In a less severe form, marginal-cost pricing for "new" customers — residents of new subdivisions, for example — might reflect the average cost of the additional supply needed for those customers. This price would be higher than that for existing customers.

It is difficult to quantify benefits provided by economic incentives since the incentives influence decisions on other management strategies that produce their own benefits. Economic incentives can be used to influence development of water supply augmentation or demand reduction programs. For example, grant funds from a State agency can reduce the

Box 8-2 Rate Structure Examples

Fixed rate – The water user pays the same amount for water each month regardless of the amount of water use. This is common where water is unmeasured (also known as a flat rate). Example: $20 water bill each month.

Uniform (or constant) rate – The water user pays the same for each unit of water. This requires measurement of water. Example: $100 for each acre-foot of water.

Tiered water rate – As use exceeds predetermined amounts, the water user pays a higher or lower rate for each unit of water. This requires measurement of water. Example of a tiered rate with increasing unit costs (also known as an increasing block rate): $1 for the first 100 cubic feet, $1.50 for the second 100 cubic feet, $2 for the third 100 cubic feet, etc.

[1] 1999 California Water Charge Survey, Black & Veatch Corporation.

effect on water rates of water recycling projects. Similarly, a wholesale water agency might make financial assistance available to retail water purveyors to encourage implementation of projects or programs that would benefit the region. Financial assistance can also be used to achieve beneficial changes in water system storage, conveyance, and treatment operations. The willingness of a water agency to participate in water marketing can also be influenced by economic incentives.

Potential Costs of Economic Incentives Policies

The only financial cost of an incentives program to a water agency is the cost of its creation and administration. Other costs would be associated with the adoption of water management strategies or water use behaviors — including foregoing some water use — that may result. The costs of the economic incentives will depend on how the incentives are integrated with other management strategies. As with other management strategies, economic incentives must be specific to the circumstances and water management goals of each individual water agency.

Major Issues Facing Additional Economic Incentives

Selecting Appropriate Water Rates

A major consideration is determining what rates to charge customers while ensuring that costs of delivering the water and treating the wastewater are recovered. Also, managing water rate changes during water shortages can be challenging since incremental costs of supply can both increase dramatically and change rapidly, making it more difficult to recover costs. If regulations against collecting revenues in excess of costs remain in effect, some agencies would have to reduce their lower tier prices in order to charge higher costs at the higher tiers. This would tend to increase use by the lower-tier customers, an undesirable result from a water use management standpoint.

Currently, if a landlord wants to charge tenants based on how much water they use, the landlord would have to comply with many of the same water quality regulations faced by utilities, including testing by experts. The EPA is now seeking a rule change to remove this barrier to individual metering.

Funding for Loans and Grants

The availability of State funding can be intermittent. Funding methods that require direct legislative appropriation or approval of new water bonds could require several years lead time before funds are available.

State Funding for Private For-Profit Purveyors

With few exceptions, State bond-funded grants and loans have only been made available to public agencies and nonprofit organizations. In 2004, in response to a query from the Governor's Office, the Attorney General issued a finding that bond funds cannot be awarded to for-profit purveyors unless the bond language specifically makes them eligible. In addition, it was determined that such language could require the issuance of taxable bonds at a substantially higher cost to the State's taxpayers.

Criteria for Loans and Grants Funding Approval

Historically, requests for loans and grants have exceeded available funding. Deciding which strategies and which agencies receive loans and grants requires setting of priorities for funding.

Social Considerations

Economic incentives can affect social equity when those customers incurring the costs of subsidization through higher taxes or fees do not receive a fair share of the benefits that the subsidies are expected to generate. As another example, increasing the costs for agricultural water supplies may increase the efficiency of on-farm water use, but can also induce changes in crop patterns that result in lower farm employment. Communities dependent on farm production may be disproportionately affected. In the urban sector, if water rate changes reduce the use of ornamental landscaping, jobs that depend on establishing and maintaining that landscaping could be lost.

Regulations

Some water agencies are not permitted to collect revenues in excess of costs. Changes in regulations may be needed to implement a water pricing policy that works best for an agency. Some water agencies have regulations that prevent the use of water metering necessary for measuring and pricing volumes of water. Typically, loans and grants are constrained by bond language to strategies that lead to capital expenditures. Most loans and grants may not be used for developing non-capital strategies such as water rate changes.

Recommendations to Help Promote Economic Incentives

The State and water agencies should consider and evaluate economic incentives as an integral part of their package of management strategies. The following recommendations recognize that economic incentives will vary widely throughout California due to differences in local conditions:

1. Institute water rates that support better water management based on the unique conditions in each water district.
    - Implement appropriate measurement of all water uses in California.
    - Use tiered pricing to the extent that it improves water management, including consideration of higher prices for water in excess of agricultural and urban vegetation management requirements.
    - Recover more costs from variable charges and fewer costs from taxes and fixed water charges as is financially prudent.
    - Institute pricing incentives that encourage the sustainable use of groundwater.
    - Institute pricing incentives that reduce excessive deep percolation of water in agricultural drainage problem areas.
    - Agencies adopting new water rates should clearly identify what they mean to water users and provide education, training, and technical assistance to water users to maximize the desired outcome of those policies.
2. Institute loans and grants that support better regional and statewide water management based on the conditions in each water district.
    - Develop ranking criteria for grant and loan awards to water agencies that consider economic, environmental, and equity issues, economic hardship, Public Trust, Environmental Justice, and the regional and statewide distribution of benefits in allocation of subsidy funds.
    - The grant and loan award process should account for the fact that some water agencies have limited funds and staffing to prepare applications.
    - Agencies receiving grants and loans should make information on the success of the programs/projects that they implement available so that the experience can be used to design better subsidy plans.
3. The State should provide technical assistance to local agencies in developing equitable and effective economic incentives to achieve local and statewide water management goals and objectives.
4. The State should develop guidelines and ranking criteria for grant and loan awards to water agencies that consider cost-effective water management, environmental and equity objectives. These guidelines and ranking criteria should account for the fact that some water agencies have limited funds and staffing to prepare applications.
5. The State should explore innovative and equitable ways to provide financial incentives to private for-profit water purveyors that avoid or minimize the perception of share holders unfairly benefiting from public funds.
6. The State should assist local agencies in using planning methods that maximize economic efficiency on a regional and statewide basis.

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Chapter 9 Ecosystem Restoration

Ecosystem restoration improves the condition of our modified natural landscapes and biological communities and makes them more sustainable for the use and enjoyment by current and future generations.

Chapter 9 *Ecosystem Restoration*

Ecosystem restoration can include changing the flows in streams and rivers, restoring fish and wildlife habitat, controlling waste discharge into streams, rivers, lakes or reservoirs, or removing barriers in streams and rivers so salmon and steelhead can spawn. Ecosystem restoration improves the condition of our modified natural landscapes and biotic communities to provide for the sustainability and for the use and enjoyment of those ecosystems by current and future generations. Healthy aquatic and wetland ecosystems benefit California's native plants and wildlife and its society and economy.

Many of California's ecosystems cannot be restored to their natural state, nor is that degree of restoration desirable. Instead, ecosystem restoration focuses on rehabilitating ecosystems so that they supply important elements of their original structure and function in a sustainable manner. Ecosystem restoration and protection can be viewed as the proper maintenance of California's natural infrastructure.

Over the past couple of decades, the public has recognized the need to restore California's ecosystems. The desire to improve the conditions of those ecosystems was supported by the passage of bond issues, such as Propositions 204, 13 and 50. Local and regional restoration projects have multiplied. There are watershed alliances and regional ecosystem projects throughout the state, including on the Los Angeles, San Joaquin, Truckee, Carmel, Sacramento, and Trinity rivers. Some of these projects are described in the regional reports of Volume 3. Most rural private lands provide wildlife habitat. See the agricultural land stewardship strategy for information of agricultural practices that preserve and enhance habitat conditions.

The decade prior to publication of this update saw a remarkable transformation in water management in California. In 1993, water management was characterized by lawsuits, policy gridlock, and conflicts between those who sought to improve water supply reliability and those who sought to protect threatened and endangered species. Since 1995, the California Bay-Delta Program has been working towards improving water supply reliability while restoring ecosystems.

Land development projects and water development projects have often had significant, if unanticipated, environmental impacts. Today, planning must include investment to prevent ecosystem damage and long-term maintenance costs. Future water projects could face conflict and opposition if they do not protect and restore the ecosystem. And water projects can help restore ecosystems because they can help ensure flows in streams and rivers at flow rates and patterns to facilitate restoration actions.

This strategy focuses on restoration of aquatic ecosystems because these are the ecosystems most likely to be affected by water management.

California's Ecosystems and Restoration

California Rivers, A Public Trust Report (State Lands Commission, 1993) concluded that the health of California's rivers is stressed and their viability as sustainable ecosystems is in peril. The report urged State agencies to undertake a comprehensive program of river basin and watershed protection and restoration. The same conclusions apply to many of California's other aquatic ecosystems, including bays, estuaries, and lakes. More recently, the California Bay-Delta Program plan for ecosystem restoration has presented broad goals, many specific objectives, and a prioritized list of actions to restore biological diversity within its geographic scope. Over the past decade, Californians have invested hundreds of millions of dollars in ecosystem restoration.

The condition of California's fisheries reveals the need for additional improvement. Thirty-three fish populations are listed as threatened or endangered in California, with some in each of the hydrologic regions described in Volume 3. These populations include coastal and Central Valley runs of steelhead; spring-run and winter-run Central Valley Chinook salmon; Delta smelt; three species from the Colorado River; and several minnows, pupfish and suckers from the Klamath basin and southern deserts.

Hydraulic mining and gold extraction in the 1800s, dam construction and operation, pollution, flood control, urbanization, increases in Delta exports and upstream diversions, and introduction of exotic species have all contributed to the decline in ecosystem health. Ecosystem changes have caused a sharp decline in the abundance of things that society values, such as native and some non-native fish species. Ability to sustain all life stages of native fish is an example of a function that California rivers no longer provide as well as they once did. People have also affected the structure of ecosystems. For example, rivers downstream of dams are deprived of the gravel supply from upstream that provides spawning habitat for species such as Chinook salmon.

The California Environmental Quality Act recognizes that human activity may have unintended environmental impacts, and outlines procedures for project proponents to avoid, minimize, and mitigate these impacts. Mitigation of environmental impacts has become common in California. Mitigation is similar to ecosystem restoration, but mitigation is intended to bring the level of ecosystem health back to what it was before impacts of a project occurred. By contrast, ecosystem restoration is intended to raise the level of ecosystem health.

Construction of major dams, increased exports through the Delta, or small local projects have been opposed for their potential impacts to the environment. It may not be possible to fully mitigate some of the impacts of new projects. When negative impacts occur in aquatic ecosystems that are already severely degraded, it may be difficult to avoid endangered species conflicts.

More recently, resource managers have concluded that the most successful way to pursue either aquatic ecosystem restoration or water management is to integrate the two. This integration of project goals has the potential to reduce the conflict over water management actions, increase the support for ecosystem restoration and provide a more cost effective solution.

Within State government, several departments and boards share public trust responsibilities. The Department of Fish and Game coordinates, oversees, funds, and carries out restoration activities and plays a central role in carrying out public trust responsibilities. The State Water Resources Control Board is responsible for regulating water rights and establishing standards for minimum stream flows. The Department of Water Resources, as the operator of the State Water Project, can propose, design, build, and operate water management facilities in ways that improve water supply reliability while restoring ecosystem health and protecting public trust values. One of these agencies cannot be completely successful unless there is collaboration among all. See Volume 1, Chapter 2, for details on the public trust doctrine and values.

Benefits of Ecosystem Restoration

Restoration can improve plant and animal life, increase diversity and connectivity of habitat, help endangered species, and improve watersheds. Restoration can rehabilitate natural processes to support native communities with minimal ongoing help. Restored habitats are likely to help sustain reproduction, foraging, shelter, and other needs of fish and wildlife species. By broadening restoration to the ecosystem level, rather than focusing on restoration for only a handful of species, we improve our chances for long-term success by incorporating species relationships, such as between predators and prey, physical processes, genetic variability, and other factors that we don't fully understand.

The state's ecosystems, from mountain watersheds to coastal beaches, are California's natural infrastructure, and support our population and economic growth. Ecosystem restoration is an investment in improving the condition of California's natural infrastructure. As understanding of the linkage between water management and the health of the natural infrastructure grows, the benefits of restoration to water supply reliability and water quality improvements are increasingly evident. As ecosystem restoration actions help increase the health and abundance of species protected under the State and federal Endangered Species Acts, there might be fewer ESA conflicts. As ecosystems such as wetlands and sloughs are restored, their natural pollutant filtering capabilities can improve water quality. As floodplains and seasonal lakes and ponds are restored, groundwater recharge can increase. The result will be a more reliable, higher quality water supply supported by a sustainable ecosystem.

The economic benefits that improved rivers, estuaries, wetlands, wildlife, beaches, and their surrounding habitats can have in the state may far exceed the investments for restoring ecosystems. Considering California lifestyle trends and travel and tourism as the major growth industry for the state, investments in ecosystem restoration actions may provide a high return on investment. Second only to the state's beaches, rivers are the biggest attraction for California's recreation industry. Similarly, managed wetlands and wildlife refuges provide bird watching and hunting opportunities that contribute hundreds of millions of dollars annually to California's economy.

Costs of Ecosystem Restoration

Detailed statewide ecosystem needs and their costs does not exist. However, it is likely that the costs of restoration are higher than the costs of protecting existing healthy ecosystems. Preliminary estimates indicate that ecosystem costs to 2030 could total $7.5 billion to $11.3 billion[1]. Costs of restoration can include research and monitoring, acquisition of land and water, cultivation and planting of native vegetation, and physical alteration of the landscape. The costs of river restoration can increase dramatically when channel alteration is required, such as filling in gravel pits or re-grading incised banks.

Since 1996, California voters have approved four bond issues that include funds to restore animal and plant life. As of the end of 2003, the California Bay-Delta Program has funded 400 projects at a cost of $490 million, and has committed $150 million per year toward ecosystem restoration.

Supplying water for ecosystem needs is often viewed as competing with supplying water for human needs, or responsible for increasing the cost of supplying human needs. While there are limits to the amount of water that can be withdrawn from a river ecosystem before its health and productivity is compromised, experience with integrating ecosystem restoration and water supply management is demonstrating their compatibility in many cases. As an example, in years 2001 through 2003 the Environmental Water Account of the California Bay-Delta Authority acquired about 900,000 acre-feet of water, at a cost of about $140 million, to protect at-risk fish species.

Major Issues Facing Implementation of Ecosystem Restoration

The major threats to aquatic and riparian habitat and freshwater biodiversity in California stem from physical changes associated with dams, diversions, and erosion protection for levees and banks; poor water quality, including temperature, dissolved oxygen levels and pollutants; and non-native invasive species. These issues are outlined further in the strategies for floodplain management, pollution prevention and watershed management in this volume. Beyond those direct physical changes, this section describes other issues and challenges facing restoration efforts.

Integrated Resources Planning

Unlike planning that is conducted for only a single-purpose, multipurpose planning that incorporates diverse interests can take longer, cost more and require better knowledge of key ecological elements and processes.

Box 9-1 Sources of Ecosystem Data

Information on restoration projects, biological resources, and organizations involved in restoration can be found for many parts of the state. The Information Center for the Environment (ICE) is a cooperative effort of environmental scientists at the University of California, Davis, and collaborators at more than 30 private, State, federal, and international organizations interested in environmental protection. ICE has developed the Natural Resources Projects Inventory, a database of information on thousands of conservation, mitigation and restoration projects being developed and implemented throughout California. Also, the California Environmental Resources Evaluation System is an information system developed by the Resources Agency to facilitate access to a variety of electronic data describing California's rich and diverse environments. The California Legacy Project, a part of CERES, has supported conservation investment decisions in numerous ways, including: (1) identified a long-range strategy to conserve the most important natural resources in California; (2) assembled a digital atlas of key resources and stressors; and (3) reported on the status and trends of those resources.

[1] Cost estimate = $7.5 billion – $11.25 billion, as follows: ($150 million/year for CALFED activities) X (25 years until 2030) = $3.75 billion for CALFED area. ($3.75 billion) X (an expansion factor of 2 or 3 to cover areas outside CALFED) = $7.5 billion – $11.3 billion

Assessment of Environmental Water Flows

Knowledge of effects of different flows on the health of aquatic and riparian ecosystems is incomplete. Data and analytical tools to measure the adequacy of flows are insufficient.

Scientific Uncertainty

Restoration science is a work in progress. Rarely do we have all the scientific information on a species, much less an ecosystem, to identify an exact course of action that will restore natural communities and processes. When precious resources and endangered species are involved, we often do not have the time or money to fully develop our scientific understanding before action is needed. Yet, the uncertainty can lead to hesitation and delay.

Sound, Accessible Data

We need more data about ecosystem health so we know where to invest public funds. There is no complete inventory of ecosystems and their health. Key criteria to prioritize conservation actions are lacking, scattered or incompatible for comparison. There is also no reporting system and incomplete metrics for evaluation of the outcome of various restoration and management strategies.

Effectiveness and Efficiency of Restoration Actions

The effectiveness and efficiency of actions taken to restore and protect aquatic ecosystems is often complex and difficult to measure. Effectiveness is the amount of benefit gained such as an increase in abundance of a species. Efficiency can be thought of as the effectiveness per unit of expenditure (e.g., money or water). Effectiveness and expenditure may not correspond one-to-one, often because factors other than the amount of funding or amount of water influence the degree of restoration achieved. The perception of wide variations in efficiency motivates a search for the more efficient alternatives. Without agreement on which alternatives those might be, opposition to further commitments, especially of water, will continue.

Funding Uncertainty

Ecosystem restoration efforts are often long term and need long-term financing. Although public funds are available, they may be sporadic and thus unreliable, and are subject to intense competition.

Gravel and Sediment

Dams retain sediment, including gravel, which is a critical element in river ecosystems. Furthermore, conventional bank protection prevents the erosion that could provide a local supply. Without a natural mechanism for replenishment of sediment, gravel must come from elsewhere. Locating sediment sources, mining gravel without causing more environmental damage and paying for long-term sediment management are significant challenges to restoring the natural functions and values of rivers below large dams.

Recommendations for Ecosystem Restoration

1. DWR, DFG and SWRCB should work together to publish comprehensive assessments of in-stream flow needs on California rivers, similar in scope to studies on the Feather and American rivers. The assessments should identify bodies of water that need improved flows, in terms of volume, timing, duration, etc.
2. The Resources Agency and Cal-EPA should work with their respective departments, boards and commissions to ensure and promote use of independent science to inform their decision-making.
3. The Resources Agency should continue to support development and use of statewide databases, analytical tools and evaluation criteria, such as the Natural Resource Project Inventory and a follow-up to the Legacy project, that can provide information to planners and decision-makers and identify priorities for restoration. This investment should provide a coordinated and comprehensive statewide implementation plan for restoration actions in each region.

DWR will incorporate ecosystem restoration as an objective in water management projects, or will partner with restoration projects, to achieve net environmental benefit from water management actions. This is consistent with the commitments that DWR has made in the California Bay-Delta Program. DWR will develop guidelines for helping local water managers and planners pursue the same multiple-objective approach, including incorporation of fish and wildlife benefits into projects. See Volume 1, Chapter 2, for more recommendations to promote integrated resource planning.

4. The Resources Agency should support further scientific research on the relationship between flow dedication and water-independent actions to achieve desired restoration. A step in this direction was the publication of a report by Deason et al. (2004) of the Graduate School of Public Policy at UC Berkeley, "Considering water use efficiency by the environmental sector." The report (see Volume 4) identifies ways to measure and compare—albeit in general terms—the efficiency of different uses of managed environmental water.
5. The Department of Fish and Game, with the Department of Conservation and DWR, should investigate and resolve key issues regarding long-term coarse sediment supplies for ecosystem needs. This investigation should identify sources of sediment, replenishment processes that will sustain themselves and potential mercury contamination.

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Chapter 10 Floodplain Management

The Yolo Bypass is an example of successful multi-objective floodplain management. Established as a floodwater corridor, it is also intensively cultivated and parts of the bypass provide outdoor recreation and spawning and rearing areas for native fish. (DWR photo)

Chapter 10 *Floodplain Management*

Floodplain management reduces risks to life and property and benefits natural resources. Floodplain management accepts periodic flooding and generally is a preferred alternative to keeping rivers in their channels and off floodplains. Seasonal inundation of floodplains provides essential habitat for hundreds of species of plants and animals, many of them dependent on periodic floods. There are also benefits to the economy, agriculture and society to keeping rivers and their floodplains connected, including water quality improvements and groundwater recharge. Examples of floodplain management objectives include:

- Minimize impacts of floods on buildings and farmland
- Remove obstacles in the floodplain, voluntarily or with compensation
- Prevent interference with the safe operation of the flood management systems
- Maintain or restore natural floodplain processes
- Educate the public about avoiding flood risks and about planning for emergencies
- Reduce flooding risks to humans

Floodplain Management in California

In the past, many flood management projects within floodplains were mostly developed to reduce property damage. They did not consider the importance of floods in maintaining a healthy environment. Likewise, some ecosystem restoration was done without considering long-term floodway maintenance. Multi-objective projects are more effective than single-purpose projects. Government and the private sector are likely to gain public support for projects with many benefits. Planners now recognize the value of floodplains by directing development away from them, avoiding or minimizing the need for major flood control structures.

An example of successful multiobjective floodplain management is the Yolo Bypass. The bypass was established as a floodwater corridor in the floodplain of the lower Sacramento River basin. It is also intensively cultivated, and its rice fields double as habitat for waterfowl and wading birds. Parts of the bypass are managed for outdoor recreation, including hunting and fishing. Portions have been planted to riparian forest, with no significant loss of flood-carrying capacity. Management of the floodplain also provides spawning and rearing areas for native fishes. In addition, several modifications to water control structures are planned to improve or restore fish passage through the bypass.

The priorities of the CALFED Bay-Delta Program Ecosystem Restoration Program (ERP) include restoration of floodplain habitat, riparian corridors and dynamic river processes such as river meandering. The ERP identifies ways to copy natural flows using reservoir releases; copy natural flows of sediment and woody debris; and provide enough high flows to cover floodplains. The program recognizes that reconnection of rivers with their floodplains may be essential for recovering many at-risk species.

A voter-approved bond issue, Proposition 13, authorized funds for a flood protection corridor program. The program supports projects that provide non-structural flood management and either preservation of agricultural land or preservation or enhancement of wildlife habitat. A second bond issue, Proposition 50, contains additional incentives for watershed-based management approaches.

In California, The Reclamation Board runs the Designated Floodway Program to reduce the impact of floods by preserving the reasonable flood-passage capacities of natural watercourses and floodways in the Central Valley. The program restricts the use of lands in Designated Floodways to agriculture, recreation and habitat, and thus retains the historical patterns of flooding. There are more than 1,300 miles of designated floodways in the Central Valley.

The U.S. Army Corps of Engineers and The Reclamation Board are examining the feasibility of a multipurpose project on the Sacramento River to include ecosystem restoration, flood damage reduction and recreation around Hamilton City. The project could restore natural floodplain processes by construction of a setback levee and restoration of about 1,200 acres of riverine habitat. A similar proposal for the San Joaquin watershed would restore natural flooding to wildlife refuges and other wetlands to cut peak flood flows and improve water quality and habitat values. This concept is under discussion among the U.S. Fish and Wildlife Service, California Department of Parks and Recreation, Grasslands Resource Conservation Districts, U.S. Army Corps of Engineers, State Reclamation Board, San Joaquin River Flood Control Association, and State and federal water contractors.

In 2000, the governor signed AB 1147, which recommended the creation of the California Floodplain Management Task Force. In February 2002, the governor delegated authority to DWR to convene the task force. With broad membership from government and stakeholders, the task force looked for ways to reduce flood damage and maximize the benefits of floodplains. The task force submitted its report in December 2002 with many recommendations (see Box 10-1 on the following pages) to promote multi-objective management of floodplains.

Benefits of Floodplain Management

Floodplain management provides many safety, ecosystem and economic benefits. By encouraging wise land use decisions along river corridors, floodplain management can save lives, improve ecosystems and reduce property and livestock losses. By making better land use decisions, more open space, such as agriculture and native habitats, could be maintained. Controlling development within the floodplain, and even removing some property from the floodplain, can significantly reduce potential future flood risk to people and property. Periodic flooding of the floodplain can provide rearing habitat that favors native fish over exotics. Reconnecting rivers to floodplains helps ecosystems and increases groundwater recharge, benefiting groundwater supplies.

Costs of Floodplain Management

Proposition 13 set aside $57 million for a Flood Protection Corridor Program. The program has funded or allotted funds to 19 projects on about 20,000 acres of habitat and agricultural lands. Many of the costs of floodplain management are associated with planning, mapping, maintenance, and emergency preparations. Construction costs depend on local conditions but can include improvements such as setback levees and elevating, or removing, buildings. Total estimated floodplain costs to year 2030 are about $475 million.[1]

Issues in Floodplain Management

Single-Purpose Approach to Floodplain Management

Due to the uncertainty of predicting floods, it is difficult to plan a flood damage reduction project that could assure long-term protection. In addition, it is difficult to obtain permits for single-purpose projects. Although integration of public safety, flood damage reduction, agricultural conservation and ecosystem protection and restoration require more time and collaboration among diverse interests, it is easier to obtain permits, funding, and more likely to achieve goals than with single-purpose projects.

Floodplain Connectivity and Inundation

Common flood management and erosion control measures, such as levees and bank armoring, separate river channels and flows from historic floodplains. A challenge for floodplain and riparian ecosystem restoration is to reconnect the floodplain with the stream and still prevent damage from floods and soil erosion. This is especially difficult and costly where houses, highways, and other encroachments could potentially sustain damage and reduce flood-carrying capacity. Restoration of large river flows is constrained below dams where regulated maximum release levels are too low to produce desired results.

Coordination

Administration, financial, and data coordination among State, federal, and local agencies is often difficult for floodplain management projects and programs. Local involvement in development of a multi-objective project is essential to satisfy the diverse interests of the stakeholders.

Recommendations for Floodplain Management

After fully considering and prioritizing all of the Governor's Floodplain Management Task Force recommendations, the following recommendations are particularly relevant to statewide and regional water management.

[1] Cost estimate = $475 million, as follows: ($57 million for Flood Protection Corridor Program, disbursed over 3 years) = ($19 million/yr) X (25 years until 2030) = $475 million

1. The State should expand its Awareness Floodplain Mapping Program for use by local governments and the public.
2. Wherever practical, floodplain maps should be prepared on a watershed basis.
3. DWR and other agencies should sponsor projects in cooperation with the United States Geological Survey (USGS) to install real-time gages in priority locations throughout California.
4. Decision-makers should gather information and data beyond Flood Insurance Rate Maps (FIRMs) to better assess reasonably foreseeable floods. Local communities should be encouraged to require new and substantially improved buildings to have their lowest floor elevations to be at least one foot above the NFIP's base flood elevation, factoring in the effect of full build out of the watershed.
5. A Multi-Objective-Management approach to flood management projects should be promoted. Flood management programs and projects, while providing for public safety, should maximize opportunities for agricultural conservation and ecosystem protection and restoration, where feasible.

Selected References

CALFED Bay-Delta Program. 2000. Strategic Plan for Ecosystem Restoration.

California Floodplain Management Task Force, 2002. California Floodplain Management Report.

Box 10-1 California Floodplain Management Task Force Recommendations Summary (December 2002)

The Task Force recommendations are organized into three categories: Better Understanding of and Reducing Risks from Reasonably Foreseeable Flooding; Multi-Objective Management Approach for Floodplains; and Local Assistance, Funding, and Legislation.

Better Understanding of and Reducing Risks from Reasonably Foreseeable Flooding

1. Awareness Floodplain Mapping — The State should expand its Awareness Floodplain Mapping Program for use by local governments and the public.
2. Future Build-Out Mapping — Local and State agencies preparing floodplain maps should consider current and future planned development.
3. Watershed-Based Mapping — Wherever practical, floodplain maps should be prepared on a watershed basis.
4. Geographic Information System (GIS)-Based Flood Maps — Local, State, and federal agencies should create, develop, produce, and disseminate compatible GIS-based flood maps.
5. Alluvial Fan Floodplains — Priority for alluvial fan floodplain mapping should be given to those alluvial fan floodplains being considered for development. The State should convene an alluvial fan task force to review information, determine future research needs, and develop recommendations specific to alluvial fan floodplain management.
6. Stream Gaging and Monitoring — DWR and other agencies should sponsor projects in cooperation with the United States Geological Survey (USGS) to install real-time gages in priority locations throughout California.
7. Repetitive Losses — Local agencies should work with the Governor's Office of Emergency Services (OES) and DWR to identify repeatedly flooded structures and inform qualifying residents of voluntary programs to prevent future flood losses.
8. Flood Warning and Response Programs — The State should increase assistance to local agencies to improve flood-warning programs specific to each watershed.
9. Flood Insurance Rate Map Issues — Decision-makers should gather information and data beyond Flood Insurance Rate Maps (FIRMs) to better assess reasonably foreseeable floods.
10. Exceeding NFIP Floodplain Management Requirements — Local communities should be encouraged to require new and substantially improved buildings to have their lowest floor elevations to be at least one foot above the NFIP's base flood elevation, factoring in the effect of full build out of the watershed.

continued

Box 10-1 continued from previous page

11. Executive Order — The Governor's 1977 Executive Order should be updated.
12. State Multi-Hazard Mitigation Plan — DWR, OES, and other agencies should incorporate into the State Multi-Hazard Mitigation Plan floodplain management measures that will meet Federal Emergency Management Agency (FEMA) requirements.
13. Multi-Hazard Mapping — OES should coordinate with other hazard mapping efforts to develop GIS-based multi-hazard advisory maps and distribute them to local governments and the public.
14. State Building Codes — Ensure that the California Building Standards Code meets, at minimum, NFIP requirements. Ensure that other State codes applicable to public buildings meet, at a minimum, NFIP requirements. Ensure that any local code adoptions or amendments and any development approvals meet, at a minimum, NFIP requirements.

Multi-Objective-Management Approach for Floodplains

15. Multi-Objective-Management — A "M-O-M" approach to flood management projects should be promoted.
16. Flood Management Approaches to Ecosystem Restoration and Agricultural Conservation — Flood management programs and projects, while providing for public safety, should maximize opportunities for agricultural conservation and ecosystem protection and restoration, where feasible.
17. Nonstructural Approaches, Restoration, and Conservation of Agriculture and Natural Lands — In planning new or upgraded floodwater management programs and projects, including structural projects, local and state agencies should encourage, where appropriate, nonstructural approaches and the conservation of beneficial uses and functions of the floodplain.
18. Tools for Protection of Flood Compatible Land Uses — The State should identify, develop, and support tools to protect flood-compatible land uses.
19. Protection of Floodplain Groundwater Recharge Areas — Permitting agencies should consider the impacts of land-use decisions on the capacity of the floodplain to recharge groundwater.
20. Vector Control — During the planning and development of ecosystem restoration projects, the costs and impacts involved with vector control and with monitoring related to mosquito-transmitted diseases should be considered.
21. Multi-Jurisdictional Partnerships — The State should encourage multi-jurisdictional partnerships when floodplain management projects are planned and implemented.
22. Watershed Monitoring — The State and others should financially support the monitoring of flood management projects on a watershed level.
23. Proactive and Adaptive Management of Floodplains — State and local agencies should manage floodplains proactively and adaptively by periodically adjusting to current physical and biological conditions, new scientific information, and knowledge.
24. Best Management Practices — DWR should work with stakeholders to identify, monitor, and update voluntary BMPs for multi-objective floodplain management.
25. Training, Education, and Professional Certification — The State should encourage the inclusion of multi-objective floodplain management curricula in college and university degree programs.
26. Coordination among Agencies and Groups — The State should encourage and create incentives for additional coordination among stakeholders.
27. State General Plan Guidelines — The State General Plan Guidelines should be updated to reflect the California Floodplain Management Task Force recommendations, as applicable, and to reflect other programs, policies, and standards, including the NFIP, for floodplain management.

continued

Box 10-1 continued from previous page

Local Assistance, Funding, and Legislation

28. New and Existing Funding Sources — The State and local governments should encourage federal, State, local, nongovernmental, and other private cost sharing to achieve equitable and fair financing of multi-objective floodplain management actions and planning.
29. Task Force Recommendation Priorities — DWR and The Reclamation Board should lead the development of a consensus process, involving appropriate stakeholders, to identify criteria and prioritize the implementation of Task Force recommendations, given the expected expenditures, using existing and new funding sources.
30. Department of Water Resources Outreach Programs — DWR should expand outreach programs to include public service announcements to increase public awareness of floodplain values, flooding hazards, public safety, and hazard mitigation measures.
31. Designated Floodways — DWR and The Reclamation Board should include, in the Community Assistance Workshops, information on the Reclamation Board's current authority to adopt and update designated floodways in the Central Valley. The Reclamation Board should work with stakeholders to identify, if any, a list of Reclamation Board regulations that are impediments to flood-compatible uses within the floodway and recommend specific revisions.
32. State Floodplain Management Assistance to Local Governments — The State should provide additional resources to continue and expand implementation of the State's floodplain management programs, including full support of the Community Assistance Contact program.
33. National Flood Insurance Program Compliance Encouragement — Public agencies not subject to local government floodplain management requirements or the Governor's Executive Order on Floodplain Management should comply with NFIP requirements.
34. Community Rating System — DWR should educate local officials and the public about the elements and benefits of the Community Rating System (CRS) insurance-rate adjusting program.
35. State CRS Program Coordinator — DWR should designate a State level CRS Program Coordinator familiar with State agencies and local governments that use the CRS program.
36. Interagency Barriers — The Reclamation Board should work with the Corps of Engineers, State agencies, local sponsors and interested parties to identify interagency barriers to efficient implementation of multi-objective flood management projects and to develop options to overcome those barriers.
37. California Environmental Quality Act Local Analysis Improvement — DWR should provide technical assistance to local agencies and practitioners with a practical, step-by-step CEQA flood hazard and impacts assessment guide.
38. Establishment of a California Floodplain Management Advisory Committee — DWR should sponsor a floodplain management advisory committee composed of local and State government representatives, floodplain managers, and other stakeholders, to develop additional recommendations to improve floodplain management practices.

Volume 2

Chapter 11 Groundwater Remediation/Aquifer Remediation

Scrubbers at McClellan Air Force Base are part of the technology used to remediate contaminated soil and groundwater. Contamination of groundwater or aquifers can result from a multitude of sources, both naturally occurring and anthropogenic. (DWR photo)

Chapter 11 Groundwater Remediation/Aquifer Remediation

Groundwater remediation involves extracting contaminated groundwater from the aquifer, treating it, and discharging it to a water course or using it for some purpose. It is also possible to inject the treated water back into the aquifer. Contaminated groundwater can result from a multitude of sources, both naturally occurring and anthropogenic. Examples of naturally occurring contaminants include heavy metals, high total dissolved solids, and high salinity from specific geologic formations or conditions. Groundwater can also be contaminated from anthropogenic sources with organic constituents, inorganic constituents, and radioactive constituents from many point and non-point sources. These anthropogenic sources include industrial sites, mining operations, leaking tanks and pipelines, landfills, impoundments, dairies, agricultural and storm runoff, and septic systems.

In the process of groundwater remediation, the groundwater flows through the aquifer toward the extraction wells where it is removed for treatment. If recharge of the aquifer continues, this flow provides a flushing action that may eventually remove most of the contaminants from the aquifer. This is also called the "pump and treat" method of remediation. Pump and treat methods transfer the contaminant to either the atmosphere or a filter material. If a volatile material is transferred from the groundwater to the atmosphere, permits must be obtained from the appropriate air pollution control district or agency for the amount to be transferred. If a filtration medium is used, such as granular activated carbon (GAC), the GAC must be disposed of as a hazardous waste. If the GAC is regenerated, the waste from that process must be disposed of as a hazardous waste. If the contaminant is radioactive, such as uranium, then residuals may need to be disposed of as radioactive waste.

Aquifer remediation is usually accomplished by treating the groundwater while it is still in the aquifer, using in situ methods involving physical or chemical treatment, biological treatment, or electrokinetics.

Another term used for either groundwater or aquifer remediation processes is groundwater restoration. Whatever the treatment method (see Table 11-1), it must be suited to the chemical (see Table 11-2) that has contaminated the aquifer. Light, non-aqueous phase liquids (LNAPLs), such as hydrocarbons, float on the surface of the groundwater. Dense, non-aqueous phase liquids (DNAPLs), such as trichloroethylene (TCE) have a specific gravity greater than water and sink to the bottom of the aquifer. Other contaminants, such as methyl tertiary butyl ether (MTBE), may be miscible in water and are in solution in the groundwater. Even with LNAPLs and DNAPLs, some of the contaminant dissolves within the groundwater in the aquifer.

Information for this entire narrative was provided by California Department of Health Services, Division of Drinking Water and Environmental Management; and by California State Water Resources Control Board, Division of Clean Water Programs.

Groundwater Remediation in California

Most remediation in California involves groundwater remediation; very little aquifer remediation takes place. There are about 18,500 sites in the state where active cleanup of contaminants is ongoing. Regulatory oversight of these cleanups is by Regional Water Quality Control Boards (Regional Boards), the Department of Toxic Substances Control (DTSC) or local agencies. About 15,000 of these sites have had a petroleum release from a leaking underground storage tank (UST) system. A petroleum release is usually detected by analyzing for total petroleum hydrocarbons (TPH) and the more soluble constituents in fuel (benzene, toluene, ethyl benzene, and xylene, commonly called BTEX). In addition to these, MTBE can be found at former leaking UST sites. Groundwater cleanup at petroleum sites almost always focuses on reduction of BTEX and MTBE because most other components of petroleum are slightly soluble in water and do not migrate far from the original source of the leak.

Table 11-1 Types of treatment

Pump and treat – groundwater remediation
Activated alumina
Biological
Blending
Coagulation/filtration
Granular activated carbon, GAC
Ion exchange, IX
Lime softening
Packed tower aeration (air stripping)
Reverse osmosis, RO
Ultra-violet photoionization
In-situ – aquifer remediation
Air sparging
Bio-sparging
Bio-venting
Cosolvents
Electrokinetics
Electron acceptors (nitrate, sulfate, ferric ions)
Electron donors (to degrade chlorinated hydrocarbons)
Fluid cycling
Hydrofracturing/Pneumatic fracturing
Soil vapor extraction
Surfactant enhancements
Thermal enhancements
Treatment walls
Vitrification

Table 11-2 List of contaminants[1]

1,2-Dibromo-3-chloropropane, DBCP
1,2-Dichloroethane
1,2,3-Trichloropropane, 1,2,3-TCP
Arsenic, As
Carbon tetrachloride, CTC
Ethylene dibromide, EDB
Methyl tertiary butyl ether, MTBE
N-Nitrosodimethylamine, NDMA
Nitrate as NO3
Nitrate + Nitrite as N
Perchlorate, ClO4
Tetrachloroethylene, PCE
Total petroleum hydrocarbons, TPH e.g, hexane, jet fuels, mineral oils, benzene toluene, xylenes, naphthalene, fluorene
Trichloroethylene, TCE
Uranium, U

[1] Some may also be called by other names

In general, cleanup for the vast majority of contaminant sites involves excavation, free-product removal if applicable, soil vapor extraction, in situ remediation, or a combination of these remediation methods. Pump and treat methodology tends to be expensive and is not employed when other effective remediation options are available. The discharge from a pump and treat system may also require a discharge permit issued by a Regional Board.

About 800 sites in California use pump and treat systems. And about a third of these are at UST sites, where shallow groundwater is typically affected. The treated-flow volumes are on the order of 10-20 gallons per minute. At a small number of sites the volume treated can be millions of gallons per day.

Volatile organic compounds (VOCs) such as TCE and tetrachloroethylene (PCE) (see Table 11-1) are being removed from groundwater in Los Angeles, from the San Gabriel basin. VOCs are also being removed in Santa Clara County. Often these cleanups are associated with federal Superfund projects, for example, the Glendale Operable Unit (OU), or the Burbank OU.

Perchlorate is being removed by ion exchange and biological treatment in Sacramento and San Gabriel basins. In Sacramento and Santa Clara, the treated water is released into a surface water channel, whereas in San Gabriel, the treated water is pumped into the public water supply distribution system.

Besides the groundwater remediation projects mentioned above, there are drinking water treatment projects for VOCs, including TCE, PCE, that are operating in various water systems (see Table 11-3). The gasoline additive MTBE is being treated in the city of Santa Monica, and in several smaller systems. Arsenic treatment is occurring in a few water systems to meet the current Maximum Contaminant Level (MCL) of 50 micrograms per liter. In 2006, the new federal MCL of 10 micrograms per liter becomes effective, and it is predicted that additional water systems will be required to treat to remove arsenic systems. Pesticides, especially 1,2-dibromo-3-chloropropane (DBCP) and ethylene dibromide (EDB), are being removed in the San Joaquin Valley and Southern California.

Nitrates in groundwater are being blended or treated in most areas of the state where agriculture has been active, either in the past or today, and wherever there are high concentrations of septic tank treatment and disposal systems.

Table 11-3 Locations of groundwater sources of drinking water with selected detected contaminants. Information provided by California Department of Health Services, Division of Drinking Water and Environmental Management

Contaminant	Counties Affected (# of sources with detections)[1]	Types of Treatment Used	Examples: Water Systems to Contact for Additional Information
Regulated Contaminants			
Inorganic Chemicals			
Arsenic (current MCL – 50 ppb[2]	Kern (10), Kings (13), San Bernardino (7), Sonoma (6), Nevada (5), Sutter (5), Los Angeles (4), Mono (4)	activated alumina; ion exchange (IX), reverse osmosis (RO), (others with limitations—see 22 CCR § 64447.2), blending	Edgemont Acres MWD; Boron CSD; Mt. Weske Estates MWC; City of Signal Hill
Arsenic (federal MCL, effective 2006 = 10 ppb)[2]	Kern (115), San Bernardino (70), Los Angeles (58), San Joaquin (56), Kings (37), Sacramento (37), Sutter (29), Sonoma (24), Riverside (20), Madera (15), Monterey (14), Fresno (13), Nevada (12), Tulare (12), Merced (10), Mono (9), Stanislaus (9), Napa (8)		
Nitrate as NO3	Los Angeles (171), San Bernardino (108), Riverside (79), Kern (64) Monterey (48), Fresno, Orange	IX, RO, blending	McFarland MWC, City of Pomona; Southern California Water Company; San Gabriel County Water District; CWS-Salinas; City of Fresno; Bakman Water Company; City of Garden Grove; City of Tustin
Nitrate + Nitrite as N	Los Angeles (80), San Bernardino (58), Riverside (31), Tulare (17), Ventura (13)		
Radioactivity			
Uranium	San Bernardino (46), Kern (38), Stanislaus (28), Riverside (28), Madera (20), Los Angeles (19); Monterey	IX, RO, lime softening, coagulation/ filtration	Cal Water, Lakeland; CWS-Salinas
Volatile Organic Chemicals			
Carbon tetrachloride	Los Angeles (95)	granular activated carbon (GAC), packed tower aeration, blending[3]	San Gabriel Valley Water Company; City of Monterey Park; La Puente Valley CWD
1,2-Dichloroethane	Los Angeles (90), El Dorado (10)		Southern California Water Company; La Puente Valley CWD
Methyl tertiary butyl ether (MTBE)	Los Angeles (6), Kern (5), Monterey, San Mateo, Madera		City of Santa Monica; Cal-Am WC – Montara; Riverview WD; CWS-V Salinas; Yosemite Spring Park Utility Company

Table 11-3 continued

Contaminant	Counties Affected (# of sources with detections)[1]	Types of Treatment Used	Examples: Water Systems to Contact for Additional Information
Tetrachloroethylene (PCE)	Los Angeles (152), San Bernardino (27), Sacramento (8), Kern (6), Fresno (5), Monterey		City of Burbank; San Gabriel Valley Water Company; City of Monterey Part; EPA-Whittier Narrows OU; City of Whittier; Southern California Water Company CWD-Salinas; La Puente Valley CWD
Trichloroethylene (TCE)	Los Angeles (196), Fresno (17), Riverside (14), San Bernardino (10), Butte		City of Burbank; City of Glendale; Cal Water Service Co, Chico; La Puente Valley CWD
Pesticides			
1,2-Dibromo-3-chloropropane (DBCP)	Fresno (121), San Joaquin (35), Tulare (35), San Bernardino (34), Madera	blending, GAC	City of Fresno; City of Clovis; City of Sanger; CalWater, Visalia; City of Lodi; City of Madera
Ethylene dibromide (EDB)	Fresno (15), Kern (11), San Joaquin (5), Madera	blending, GAC, packed tower aeration City of Fresno;	City of Madera
Unregulated Contaminants (No MCL) **Inorganic chemical**			
Perchlorate (MCL to be established—see DHS website for status)	Los Angeles (134), San Bernardino (80), Riverside (61), Orange (31), Sacramento (13), Tulare (8), Santa Clara (7)	IX, biological, blending	California Domestic WC; La Puente Valley CWD; City of Redlands; San Gabriel Valley WC-Fontana; City of Riverside; City of Colton; City of Rialto; So Cal Water Co., So San Gabriel; City of Morgan Hill
Semivolatile Organic Chemical			
N-Nitrosodimethylamine (NDMA)	Los Angeles (~5)	UV photoionization	San Gabriel Valley Water Company; City of Industry; La Puente Valley CWD
Volatile Organic Chemical/Pesticide			
1,2,3-Trichloropropane (1,2,3-TCP)	Kern (75), Los Angeles (29), Fresno (23), Tulare (18), San Bernardino (16), Merced (13); Riverside (7), San Joaquin (7), San Diego (6), San Mateo (5), Stanislaus (5)	see VOCs above	City of Burbank

[1] The numbers of sources are from the DHS database, including analyses reported 1994-2002 www.dhs.ca.gov/ps/ddwem/chemicals/monitoring/results94-02.htm except for MTBE, perchlorate, and 1,2,3-TCP, which are through 2003 www.dhs.ca.gov/ps/ddwem/chemicals/chemindex.htm. Arsenic data are from 2000-2002 www.dhs.ca.gov/ps/ddwem/chemicals/arsenic/newmcl.htm, and the NDMA estimate is from the narrative at www.dhs.ca.gov/ps/ddwem/chemicals/NDMA/history.htm. For "Regulated Contaminants" the number in parenthesis represents detections greater than MCLs. For "Unregulated Contaminants of Interest" the number represents overall detections. In general, counties with only a few detections are not included, unless an example of a water system providing treatment is provided in a particular county.
For more information on drinking water treatment technologies, contact the local DHS drinking water office (see the DHS website for office locations), or contact specific water systems that are addressing a contaminant problem.

[2] Arsenic currently has an MCL of 50 ppb. In 2006, compliance with a new federal MCL of 10 ppb is required. This will increase the number of sources will detections greater than the MCL from a total of about 70 80 to over 600.

[3] Some systems are or may be considering use of advance oxidation processes, such as ultraviolet, or ozone for VOC treatment.

Potential Benefits from Remediation of Groundwater

The potential benefits of remediating contaminated groundwater so the water can be used as a part of the available water supply are:

- An additional water supply is available that would not be available without remediation
- The cost of buying an alternative water supply is avoided
- Eventually, through the flushing action, the aquifer may be cleaned to the point that treatment is no longer required
- Treated groundwater may be blended with other water supplies to increase the total available water supply
- Groundwater from remediation projects and blended supplies that do not meet drinking water or other high water quality requirements may still be available to meet water needs that do not require such high quality water, thus increasing the overall water supply
- Groundwater basins are protected from other threats including additional contamination caused by plume migration, limits to the spatial and temporal flexibility of pumping within a basin, and limits to groundwater banking and conjunctive use within the basin.
- A supply is maintained that is used throughout the state to meet up to 40 percent of the state's water demand.

Potential Costs

The cost of remediating groundwater includes:

- Cost of characterizing the groundwater or aquifer, in terms of all the contaminants present
- Capital cost of the system, whether groundwater or aquifer remediation
- Operation and maintenance costs during the life of the project; remediation may be required for a long time.

Except for responsible parties reimbursed by the Underground Storage Tank Cleanup Fund (Fund), it is difficult to estimate the cost of cleaning contaminated sites. However, the Fund reimburses about $180 million annually to eligible claimants. It is estimated that major oil companies that have not been reimbursed are expending about $50 million to $100 million annually on their sites. Therefore, costs associated with the cleanup of all UST sites in California appear to easily exceed $300 million annually. The cost to clean up an individual UST site typically ranges from $100,000 to $200,000. The cleanup of UST sites that are also contaminated with MTBE is costing significantly more than the average, with reimbursements as high as the Fund limit of $1.5 million per site.

The cost of cleaning up non-UST sites is also highly variable. A site where solvent contamination has reached groundwater may require continuous pump and treat operation for decades and cost millions of dollars.

Based on cost data from the State Water Resources Control Board and the California Department of Health Services, Division of Drinking Water and Environmental Management, total groundwater remediation costs in California could approach $20 billion over the next 25 years. The estimate is based on current costs for remediation, estimated future costs for similar remediation, newly discovered contamination, and emerging contaminants.

Groundwater remediation also avoids the costs of losing the aquifer as a water supply. These avoided costs include:

- Cost of an alternative water supply
- Long-term foregone profits and taxes from businesses and activities that decide not locate in the basin because of water shortages
- No opportunity for development of residential areas because there is no water supply available
- Contaminant may spread further, requiring greater and more costly remediation in the future.

Major Issues Relating to Groundwater Remediation

Water Quality

Several groundwater quality issues complicate remediation efforts. The types and the concentration of the constituents vary from aquifer to aquifer. Contaminated water associated with a hazardous waste facility, Superfund site, and other sites may contain a variety of regulated and unregulated contaminants. Non-point source contamination such as nitrates or elevated levels of boron or salts in agricultural areas can be widespread in the subsurface and can leach into the groundwater from surface infiltration or rising groundwater levels. Contaminated water may be poorly characterized, in terms of the contaminants that are present and locating the dimension of the plume is costly. The sources of the contamination need to be found and eliminated (or the amount of contaminated discharge reduced), so that the groundwater basin can be cleaned. There is always potential for other contaminants being detected subsequently that could cause the need for additional treatment facilities.

Water Quantity

Lack of knowledge about the geometry and characteristics of the aquifer complicates groundwater remediation. Without this information it is not possible to develop a water budget for the remediation.

Costs of Treatment

Cost questions can impede groundwater remediation. Who will pay, who are the responsible parties, and what is the appropriate share for each responsible party? Groundwater treatment is expensive and it can take years or decades to remediate contaminated groundwater sites. Delays in implementing groundwater remediation while the contaminants spread can significantly increase the cost and time required for cleanup. This is especially true if long-term litigation is involved to determine responsible parties.

Recommendations to Help Groundwater Remediation

The following recommendations for State action can help protect groundwater quality and remediate when necessary to maintain California's water resources:

1. Provide additional funding where appropriate to help local agencies and governments implement remediation projects where no financially solvent responsible parties exist.
2. Identify the responsible parties, so that they can provide funding to build treatment facilities and operate and maintain them.
3. Provide technical assistance for remediation projects, particularly where no financially solvent responsible parties exist.
4. The State (SWRCB, RWQCBs, DTSC, DWR) should compile information on currently operating remediation projects, including:
    - Contaminant(s) involved
    - Amount of contaminant(s) in the aquifer that must be removed, which will require many more monitoring wells
    - Type of treatment
    - Expected length of operation of the treatment project, which is directly dependent on the data collected
    - Capital cost of the project
    - Annual operating and maintenance cost, including costs of waste disposal
    - Amount of groundwater treated per unit time
    - Seasonality of volume treated (the amount may vary seasonally depending on usage)
    - Number of wells extracting groundwater
    - Number of connections served
    - Measures that could have prevented the contamination
5. Provide local governments and local agencies with State assistance to implement source water protection measures based on the source water assessments that were completed as of 2003 to protect recharge areas from contamination to prevent future contamination.
6. Provide State assistance to local agencies to prevent contamination of recharge areas.
7. The State should develop techniques to inventory, model and evaluate feasible actions to improve the long-term availability of groundwater and the long-term quality of groundwater as a vital component of California's water resources for beneficial uses.
8. Local government and local agencies should limit potentially contaminating activities in areas where recharge takes place and work together to develop a sustainable good quality long-term water supply for beneficial uses.

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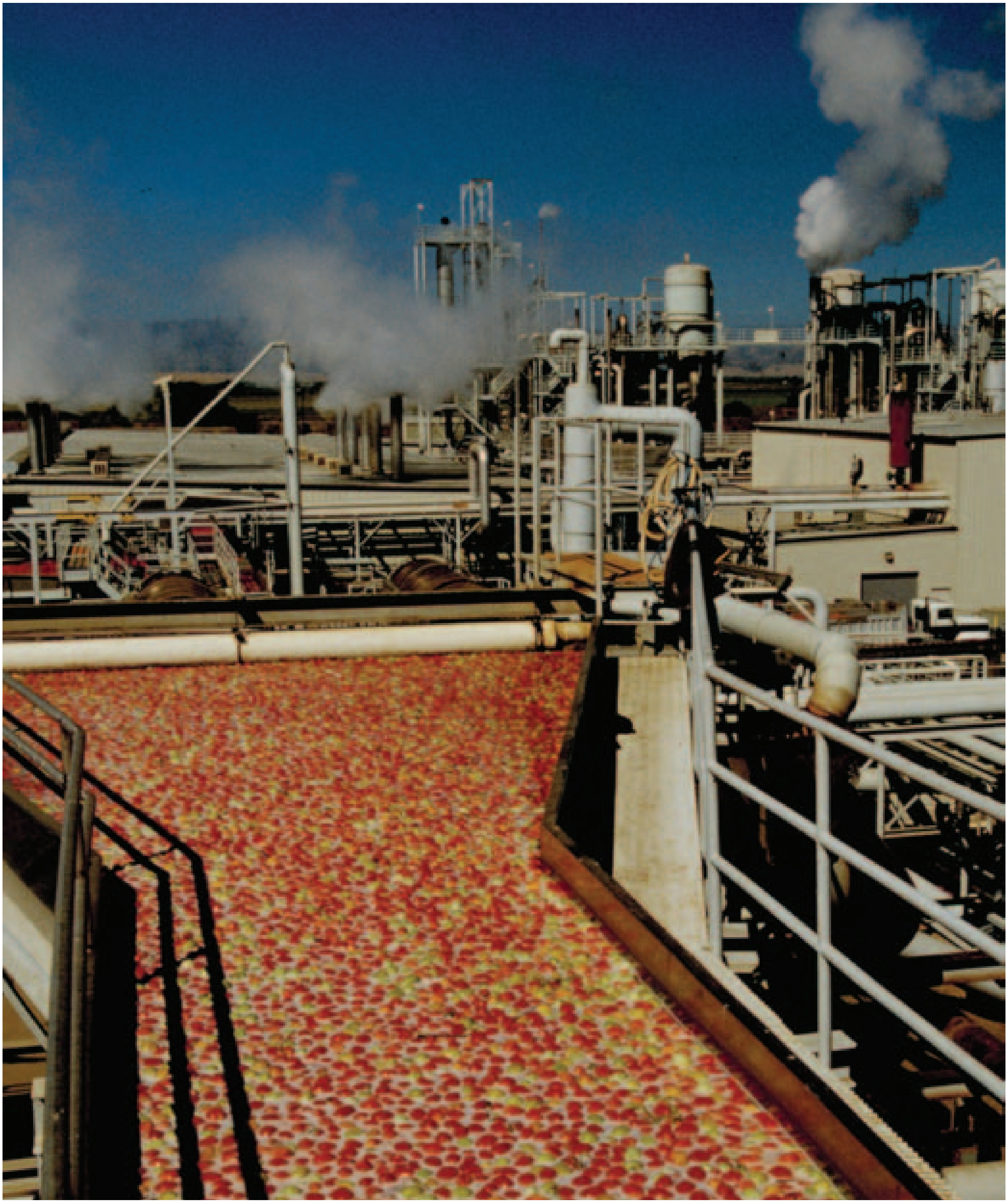
Chapter 12 Matching Water Quality to Water Use



Matching water quality to water use is a management strategy that recognizes that not all water uses require the same quality water. This tomato processing plant near Williams does not require the same quality of water as a computer chip plant. (DWR photo)

Chapter 12 *Matching Water Quality to Water Use*

Matching water quality to water use is a management strategy that recognizes that not all water uses require the same quality water. One common measure of water quality is its suitability for an intended use, and a water quality constituent is often only considered a contaminant when that constituent adversely affects the intended use of the water. High quality water sources can be used for drinking and industrial purposes that benefit from higher quality water, and lesser quality water can be adequate for some uses, such as riparian streams with plant materials benefiting fish. Further, some new water supplies, such as recycled water, can be treated to a wide range of purities that can be matched to different uses. The use of other water sources, again, like recycled water, can serve as a new source of water that substitutes for uses not requiring potable water quality.

Status of Water Quality Matching in California

SWRCB has identified 23 beneficial use categories of water, for mostly human and in-stream uses. Human uses can be categorized as consumptive, such as municipal, agricultural, and industrial supplies, and non-consumptive, such as navigation, hydropower generation, and recreation. Matching water quality to most of these uses is important because, except for municipal and industrial uses, water is generally used as-is, without treatment.

Farmers currently match crops to the available water quality. In general, irrigation water should contain levels of constituents such as salinity and boron that will not inhibit the yields of some crops. Conversely, agricultural water supplies that have low levels of salts may require adding gypsum to improve percolation. Agricultural water supplies may require filtration to remove particulate matter that could clog low pressure irrigation systems and reduce soil infiltration rates. As an extreme case, Imperial Irrigation District runs all water that it diverts from the Colorado River at Imperial Dam through siltation basins to remove suspended particulate before the water is released into the All American Canal.

Alternatively, ambient, in-stream water must be suitable to support a wide range of aquatic habitats and conditions. Thus, water quality for in-stream uses generally must be free of a variety of contaminants, not just a few. One particular pollutant that greatly affects fisheries is temperature. An example of an effort made to match water quality to an environmental use for that particular pollutant is the Temperature Control Device at Shasta Dam, which was built to better match water temperature to the reproductive needs of salmonid fish downstream.

For drinking water supplies, it is important to start with the highest quality source water possible. Historically, California's urban coastal communities, Los Angeles, San Francisco, Oakland and Berkeley, constructed major aqueducts to such sources as Hetch Hetchy, Owens Valley, and the Mokelumne River. Later, water supplies of lesser quality, such as the Sacramento-San Joaquin Delta and the Colorado River, were also tapped for domestic water supplies. In response, many utilities already manage water quality by blending higher quality water supplies with those of lower quality, as well as matching treatment process to source water quality, as required by regulation. For example, Metropolitan Water District of Southern California (MWD) dilutes high salinity Colorado River water with lower salinity water from the Bay-Delta, which improves public acceptance of tap water, as well as facilitates groundwater recharge and wastewater recycling projects. In turn, MWD dilutes the higher bromide and organic carbon levels in Delta water with Colorado River water, to help reduce disinfection by-products in treated water. In Solano County, higher quality, less variable Lake Berryessa water is blended with lower quality, highly variable North Bay Aqueduct water from the Delta. Likewise, many water suppliers have the capability to blend groundwater, local surface water, and imported supplies to achieve a desired water quality, although some utilities may instead choose to use water supplies based upon cost minimization or water rights considerations. Some water agencies even blend water (and water quality) from different levels of the same reservoir, by using different intake levels. Many water management actions, such as conjunctive use, water banking, water use efficiency, and water transfers, intentionally or unintentionally, result in one type of water quality traded for, or blended with, another.

Business also matches water quality to use. Water used in high-technology applications is often purer than that used for drinking. For instance, Silicon Valley manufacturers and other businesses in the San Francisco Bay Area prefer higher quality Hetch Hetchy water to Delta or groundwater supplies that are also available in the region. For other uses, lower quality waters can be used. Cooling water used in production is often of a lower quality than that used for drinking. The Central and West Basin Municipal Water Districts offer different qualities of recycled water — at different costs — tailored to different uses, including process water for petroleum refining. At least one concrete plant in San Francisco captures and reuses its low quality stormwater runoff for concrete production.

CALFED identified two potential water quality exchange projects, the San Joaquin Valley-Southern California Water Quality Exchange Program, and the Bay Area Water Quality and Supply Reliability Program, to improve water quality and water supply reliability — as well as disaster preparedness — on a regional basis. These programs could promote matching water quality to water use, with potentially no degradation to the ultimate use of the water. For instance, in the Bay Area, a local water agency with access to a water supply of relatively lower water quality could fund water recycling or water conservation projects in another agency's service area that has a higher quality water supply, in exchange for the higher quality water saved by those projects. Under the San Joaquin Valley-Southern California Water Quality Exchange Program, MWD is working with both the Friant Water Users Authority and the Kings River Water Association to investigate the feasibility of exchanging water supplies. MWD is interested in these exchanges to secure higher quality Sierra water supplies that could result in treatment cost savings and an increased ability to meet more stringent drinking water quality regulations. In return for participating in the water quality exchange, Friant and Kings are interested in securing infrastructure improvements, financed by MWD, which will increase water supply reliability for their members.

Potential Benefits

For agricultural and in-stream uses, water quality matching is an integral part of water quality management, because there is generally no treatment of these water supplies prior to their use. For drinking water, appropriately matching high quality source waters can reduce the levels of pollutants and pollutant precursors that cause health concerns in drinking water. In addition, less costly treatment options can be used when water utilities start with higher quality source waters, and water supply reliability can simultaneously be enhanced.

For municipal and industrial customers, using water high in salinity can cause economic costs through damages to plumbing and fixtures and water-using devices and equipment. One study, conducted in 1998 by the U.S. Department of the Interior and the MWD, found that for every 100 mg/L decrease in salinity, there is an economic benefit of $95 million annually to MWD's customers.

Improved treated water quality and water supply reliability are also potential benefits of water quality matching for those agencies that have access to a diverse water supply portfolio. One example is the Santa Clara Valley Water District, its retail agencies, and other water suppliers along the South Bay Aqueduct, which have access to Delta water, Hetch Hetchy, local surface water, and groundwater. During droughts, seawater intrusion increases the level of salinity in Delta water supplies, including bromide. In such an event, agencies and regions with water source flexibility could use more groundwater or local surface water, if available, both of which are relatively bromide-free and thus do not create bromate, a potential carcinogen, upon disinfection with ozone.

Potential Costs

Water that contains lower levels of salinity is a better match for domestic water quality uses and for irrigating salt-intolerant crops such as strawberries and avocados. As noted, some agencies blend water supplies to achieve a desired water quality, including salinity. If low salinity water supplies are unavailable, water utilities may instead have to treat high salinity water supplies to achieve a desired water quality. In the Chino Basin, utilities already demineralize (desalt) water for domestic use, and Zone 7 Water Agency and Alameda County Water District have similar plans. At ACWD, for example, the capital costs alone of its new groundwater desalting project in Newark were $1.3 million per acre-foot per day of capacity, with operations and maintenance costs of $500 per acre-foot. In some cases, costs for matching water quality to use will also include new conveyance systems to connect different source waters.

CALFED estimates that it will spend just under $100 million (in 2004 dollars) on water quality exchanges during Stage 1 implementation. The primary costs of water quality exchanges are: infrastructure, conveyance (such as energy, capacity, and hydraulic losses), and incentive payments for participants (i.e., the incentive driving the Friant/Kings-MWD programs is MWD's willingness to invest in local infrastructure that will benefit the exchange partner). In 2003, however, a "no-cost" water quality exchange was implemented between the Environmental Water Account (EWA), Kern Water Bank, and MWD. Under the exchange, EWA had purchased groundwater in Kern Water Bank and was seeking to avoid a storage fee for leaving the purchased water in the bank. MWD offered to receive EWA's purchased water in exchange for providing the EWA with a surface water supply later in the year when EWA could use the water. MWD benefited from the exchange because it received groundwater supplies with low total organic carbon and bromide levels during a period when MWD was unable to blend total organic carbon levels down with Colorado River supplies. Other "no cost" exchanges are being explored that are similar to this arrangement. One example is for an urban water user to provide agricultural water users with surface supplies during the peak agricultural water demand period, when agricultural users are forced to use groundwater and may be facing pumping constraints. In return, the agricultural user would return a like amount of pumped groundwater during the fall-winter period when there is excess groundwater pumping capacity and bromide and total dissolved solids in Bay-Delta supplies are higher. In addition to water supply benefits, use of Delta water in groundwater recharge and banking operations may also provide water quality benefits as well by substantially reducing levels of turbidity, pathogens, and organic carbon upon withdrawal.

Major Issues

Many of the issues of matching water quality to use are integrally connected to pollution prevention.

Water Transfers

Water quality exchanges face similar regulatory, institutional, and third-party impact issues that water supply transfers face (please see the Water Transfers narrative for a discussion of those issues). In particular, water supplies are generally governed by place-of-use restrictions that must be addressed when exchanging water supplies. Moreover, water quality exchanges could have adverse third-party impacts, such as increasing the salinity of local groundwater, reducing the availiability of higher quality in-stream water needed for fisheries, and limiting agriculture to salt-tolerant crops. For drinking water, an exchange could also trade bromide and organic carbon, precursors to contaminants with probable risks, for arsenic, one of the few known carcinogens regulated in drinking water.

Unusable Water

There is often a high cost incurred by water supplies that become either unsuitable for certain uses, or very expensive to use, because of contamination. One specific example, cited in a recent study by the Environment California Research and Policy Center, is the contamination by methyl tertiary-butyl ether (MTBE, a gasoline additive that may cause cancer), which initially closed 80 percent of Santa Monica's drinking water wells, in turn forcing that city to increase its dependence on imported water sources, and later to install treatment to reduce MTBE levels. More generally, nitrate has closed more public water supply wells in California than any other contaminant, often permanently redirecting the use of such contaminated water to irrigation.[1]

Salinity

Agricultural drainage, imported Colorado River water, and seawater intrusion in the Delta and coastal aquifers all contribute to increasing salinity in all types of water supplies, which can adversely affect many beneficial uses, including irrigation, fish and wildlife, and domestic use. The primary tool to reduce salinity impacts is matching water quality to use, because many sources of salinity, such as seawater intrusion, are natural, and treatment to remove salinity is relatively expensive. Further, water supplies that are high in salinity increase the cost of recycling or recharging these supplies in aquifers for subsequent reuse.

Operations Criteria for Storage and Conveyance

Water quality currently plays a relatively minor role in the operation of most local, State, and federal water projects. Most reservoirs and other projects, such as water transfers and the Environmental Water Account, are operated to achieve goals and objectives related to water supply, power production, flood control, fish and wildlife protection, and even recreation—but not water quality. In the Delta, the only water quality standards for project operations are for salinity,

[1] For a fuller discussion, please see the Aquifer Remediation narrative.

to protect agricultural, in-stream, and municipal and industrial uses. However, these ambient water quality standards do not reflect water user demand for lower salinity water supplies. Moreover, other parameters of concern for domestic uses, such as pathogens and organic carbon, do not have operating criteria and, further, do not have objectives in basin plans or discharge requirements in NPDES permits.

Upstream and Downstream Partnerships

Presently, few partnerships exist between upstream source water areas, downstream water users, and the water users in between that affect water quality, resulting in a critical disconnect in the overall system. Such partnerships could lead to pollution prevention or trading opportunities that could result in more efficient water quality protection.

Ecosystem Restoration and Drinking Water Supplies

Some ecosystem restoration projects, such as wetlands restoration, may improve habitat and even some aspects of water quality, but at the same time, may degrade other aspects of water quality, such as mercury or organic carbon (from a drinking water perspective). The CALFED Bay-Delta Program is actively investigating this potential conflict in matching water quality to use (see Ecosystem Restoration narrative).

Recommendations to Improve Water Quality Matching

1. The State, local water agencies, and regional planning efforts should manage water supplies to optimize and match water quality to intended uses and available and appropriate treatment technology.
2. Consistent with the watershed-based source-to-tap strategy recommended in the Pollution Prevention narrative, the State should help facilitate system-wide partnerships between upstream watershed communities and downstream users along the flow path, in order to seek ways to better match water quality to use.[2]
3. The State should facilitate and streamline water quality exchanges that are tailored to better match water quality to use, while mitigating any adverse third-party impacts of such transfers, as well as ensure that place-of-use issues are addressed in a manner that protects an exchange participant's water rights.
4. The State and local agencies should better incorporate water quality into reservoir, Delta, and local water supply operations, as well as facility re-operation and construction. For example, the timing of diversions from the Delta, and thereby the concentrations of salinity and organic carbon in those waters, could be better matched to domestic, agricultural, and environmental uses. Alternatively, the timing and location of urban and agricultural discharges to water sources, including the Delta, could also be coordinated with the eventual use of water conveyed by potentially impacted diversions. Facilities conveying municipal and industrial water could also be separated from those conveying water for irrigation.
5. To facilitate water reuse downstream, the State should encourage upstream users to minimize the impacts of non-point urban and agricultural runoff and treated wastewater discharges.

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[2] More information on this watershed-based approach can be found in the Pollution Prevention and Watershed Management narratives.

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Chapter 13 Pollution Prevention

Federal and State permits, enforcement, remediation, monitoring, and watershed-based programs are some of the tools used to prevent pollution. The National Water Quality Inventory in 2000 found urban and agricultural runoff is the primary source of water pollution in the United States. (DWR photo)

Chapter 13 *Pollution Prevention*

Pollution prevention can improve water quality for all beneficial uses by protecting water at its source, reducing the need and cost for other water management and treatment options. By preventing pollution throughout a watershed, water supplies can be used, and re-used, for a broader number and types of downstream water uses. Improving water quality by protecting source water is consistent with a watershed management approach to water resources problems. In addition, the legal doctrine of "public trust" demands that the State protect certain natural resources for the benefit of the public, including uses such as fishing, protection of fish and wildlife, and commerce, all of which are affected by pollution.

Status of Pollution Prevention in California

There are many tools — regulatory, voluntary, or incentive-based — currently available for preventing pollution. The U.S. Environmental Protection Agency, State Water Resources Control Board, and Regional Water Quality Control Boards have permitting, enforcement, remediation, monitoring, and watershed-based programs to prevent pollution. Pollution can enter a water body from point sources like pipes and from nonpoint sources over a broad area like sedimentation along a long river reach. Preventing pollution from most point sources relies on a combination of source control and treatment, while preventing nonpoint source pollution generally involves the use of best management practices (BMPs) and efficient water management practices (EWMPs). The SWRCB and RWQCBs are adopting total maximum daily loads (or TMDLs), to control both point and nonpoint source pollution, in those water bodies that are not attaining their water quality standards. Nonpoint source (NPS) pollution is responsible for 76 percent of the impairments in California's waters. The SWRCB and RWQCBs are also focusing on water quality issues related to abandoned mines, the U.S.-Mexico border, and beach closures. USEPA and the Department of Heath Services (DHS) have sanitary survey and source water assessment programs specifically for drinking water sources. Beyond these State and federal efforts, many local agencies, businesses, farmers, non-governmental organizations, and watershed-based groups are preventing pollution directly, on their own or through partnerships.[1]

Surface Water Quality

As approved by USEPA, the State's official evaluation of its surface water quality is the SWRCB's biennial water quality assessment and the Clean Water Act 303(d) List of Water Quality Limited Segments. In 2002, California listed 685 water bodies on the 303(d) list, which exceed established water quality objectives. In some cases, a water body is listed for more than one pollutant, and in total, there are currently 1,883 pollutant water-body listings. About 13 percent of the total miles of California's rivers and streams, and about 15 percent of its lake acreage, are now listed as limited under the 303(d). Water bodies are most often listed as impaired for pathogens, nutrients, pesticides, metals, and organic chemicals. The potential sources most often noted as the cause of impairments are unspecified nonpoint sources, source unknown, agriculture, urban runoff, and natural sources. As of 2002, advisories warning against fish consumption, an indirect indicator of surface water quality, were posted for 18 percent of California's lakes, while less than 1 percent of the state's rivers were similarly posted.

[1] Please refer to Volume 1, Chapter 3, for a more detailed discussion of the legal and regulatory framework for protecting ambient water quality.

Groundwater Quality

Although standards or objectives do not cover all water quality contaminants, for example, perchlorate, 62 percent of wells reviewed by DWR's Bulletin 118 (California's Groundwater), using data provided by DHS, met Title 22 of the California Code of Regulations maximum contaminant levels (MCLs) for the period 1994-2000. However, in each of the state's hydrological regions, a 24 percent to 49 percent of public water supply wells exceeded one or more MCLs, usually for inorganic chemicals or radioactivity.[2] As a result of man-made contamination from agricultural practices and septic tanks, nitrate, which presents a known, short-term health risk, has closed more public water wells statewide than any other contaminant. Other groundwater contaminants of concern, including arsenic and hexavalent chromium (or chromium-6), are chronic (i.e. long-term health risks, such as cancer or reproductive and endocrine system dysfunction. Another common groundwater contaminant, salinity—while not a health risk—is a concern for water palatability as well as water facility longevity. A different indicator of groundwater quality, leaking underground fuel tanks, has steadily declined after peaking in 1995, due primarily to the success of regulatory action. In addition to underground storage tanks, older landfills and hazardous waste disposal sites are also common sources of groundwater contamination, and abandoned wells can provide a ready conduit for aquifer contamination.

Environmental Water Quality

Throughout California, water quality impairments threaten riparian and aquatic habitats, and in some cases are major impediments to ecosystem restoration. Urban, military, industrial, hydropower, mining, logging, agricultural, grazing, and recreational activities can degrade water quality. Depleted freshwater flows as a result of upstream dams, diversions, and interbasin transfers, also affect the quality of water downstream, and have public trust doctrine implications. Other water management actions and projects, such as conjunctive use, conveyance, transfers, and conservation, can also affect water quality, both positively and negatively. Many significant pollution problems today are the result of persistent "legacy" pollutants, such as mercury, extracted from the Coast Range and used to process gold in the Sierra mines in the 19th century, and industrial chemicals such as polychlorinated biphenyls (PCBs), used in electrical transformers. These pollutants also contaminate sediments, making ecosystem restoration efforts more difficult. Hydraulic mining during the 1900s still has an adverse impact on numerous Central Valley rivers as well as San Francisco Bay. Some environmental contaminants of concern, such as mercury and selenium, are persistent or bioaccumulative — that is, their concentration and toxicity magnifies in the food chain — and can be toxic to key food chain links, such as aquatic invertebrates, and negatively impact communities and tribes dependent upon subsistence fisheries.

Drinking Water Sources

Public water systems in California have about 15,000 groundwater and 1,000 surface water sources of drinking water. About 4,000, or a quarter, of these sources have at least one detection of a regulated contaminant, usually from man-made sources, at a level greater than its MCL. The data specifically show a steady increase in the number of wells that exceed MCLs for nitrate and arsenic; moreover, the MCL for arsenic, a naturally-occurring contaminant, will drop further in 2006, affecting another 900 drinking water sources. Uranium, a naturally occurring radionuclide, and the organic chemicals trichloroethylene (TCE, an industrial solvent), 1,2-dibromo-3-chloropropane (DBCP, a now-banned nematocide) and methyl tertiary-butyl ether (MTBE, a gasoline additive), also frequently pollute drinking water sources. In addition to the one for arsenic, California will soon adopt new MCLs for perchlorate and hexavalent chromium.

DHS, with the assistance of 34 counties and 500 water systems, recently completed source water assessments for 15,000 public drinking water sources in California. Initial evaluation of the assessment results indicates that groundwater sources (about 14,000 wells) are most vulnerable to septic tanks and sewage collection systems. Surface water sources are most vulnerable to surface water recreation and septic tanks. These assessments, combined with water quality monitoring, suggest that California is not doing enough to prevent nitrate pollution, an acute health hazard to infants and developing fetuses, the MCL for which has the lowest margin of safety of all regulated drinking water contaminants.

One particular water source, the Hetch Hetchy water supply (Tuolumne River) which serves more than 2 million people in the San Francisco Bay Area, does not require filtration because of pollution prevention measures in its protected, Sierra watershed. Generally, forested watersheds play an important role in protecting water quality.

[2] The DHS database, though, only covered wells in about half of the groundwater basins in the state. And even for those basins that have wells in the database, the water quality in those wells is not necessarily representative of the water quality throughout the basin.

Another drinking water source, the Sacramento-San Joaquin Delta, provides some portion of the water supply for more than 22 million Californians. A unique aspect of this water source is that seawater introduces relatively high levels of bromide that, upon disinfection in a domestic water treatment plant, can contribute to the formation of disinfection by-products, such as trihalomethanes and bromate, which are potential carcinogens. Those water systems near the Delta that use it as a source of drinking water are also challenged by algal blooms as well as fluctuating levels of pH, turbidity, and alkalinity.

Potential Benefits

For the vast majority of contaminants, it is generally accepted that a pollution prevention approach to water quality is more cost-effective than end-of-the-pipe treatment of wastes, or advanced domestic water treatment for drinking water. Pollution prevention measures are usually more cost-effective because they have lower initial capital costs, as well as less ongoing operations and maintenance costs, than traditional engineered treatment systems. However, because of the nature and sources of some contaminants, like bromide (introduced by seawater) and organic carbon (natural runoff from the watershed), a pollution prevention approach may not be possible, cost-effective, or even desirable in some instances. Small water systems, which generally lack technical and financial capacities, may be more reliant upon pollution prevention measures than other options available to larger systems, such as advanced treatment. High-quality near-shore coastal waters provide multiple benefits or uses by providing recreational opportunities, as well as serving as a water source for desalination plants, and habitat for wildlife.

Potential Costs

According to the 2000 USEPA Clean Water Needs Survey, California has more than $14 billion of needs to prevent both point source and nonpoint source pollution.[3] This survey, though, emphasized point source discharges, which represented more than $13 billion of the needs, and likely underestimated the cost of measures to adequately prevent nonpoint source pollution. In terms of drinking water quality, investments in pollution prevention measures may entail more risk and uncertainty in improving water quality relative to advanced domestic water treatment options.

Major Issues

Urban Impacts

USEPA's most recent National Water Quality Inventory in 2000 found that pollution from urban and agricultural runoff are the primary sources of water pollution in the U.S. Urban runoff and stormwater wash pollutants, such as nutrients (lawn fertilizers and pet wastes), pesticides, oil and grease, metals, organic chemicals, microorganisms, and debris, from city streets and other hard surfaces, that impair surface waters (including beaches) and negatively impact existing and future groundwater replenishment projects that use stormwater for recharge (see Urban Runoff Management, and Recharge Area Protection strategies).

Agricultural Impacts

Agricultural drainage can impair water supplies with relatively high levels of salinity, nutrients, pesticides, sediment, and other contaminants, as can wastes from dairies and feedlots, which are high in nitrates and microbes. In the Central Valley, the Regional Water Quality Control Board has endorsed the use of farm-based watershed groups to monitor water quality and implement best management practices (BMPs) and efficient water management practices (EWMPs) to control nonpoint source pollution from 7 million acres of irrigated lands (i.e., crops, nurseries, and managed wetlands).

Natural Impacts

Arsenic, asbestos, radon, minerals, and sometimes microbes and sediment are examples of naturally occurring contaminants for which a pollution prevention approach is obviously infeasible. Furthermore, some contaminants that are concerns specifically for drinking water, such as organic carbon from watershed runoff and bromide — a component of ocean salinity, are a result of natural processes for which a pollution prevention approach may not be possible, effective, or even appropriate. As an example of the latter, organic carbon, while problematic for drinking water treatment, is a necessary and beneficial component of the ecosystem. While of course not ignoring pollution prevention opportunities, the use and integration of other water quality management tools, such as matching water quality to water use and drinking water treatment and distribution, may be more effective and appropriate for these latter two drinking water contaminants.

[3] Cost estimate adjusted to $15 billion in 2004 dollars.

Emerging Contaminants

Traditionally, water agencies focus on pathogens (disease–causing microorganisms), chemicals, and disinfectant by-products (potential cancer-causing contaminants), that are regulated or will be regulated in near future. Recently, though, unregulated chemicals found in pharmaceuticals and personal care products are emerging as water contaminants. For instance, as the state's population ages, there may be increasing levels of pharmaceutical discharges in domestic wastewater and to the environment. Such contaminants might not be removed by traditional treatment processes, and can negatively impact water recycling and groundwater recharge projects.

Population Growth Demands and Impacts

Future population growth and land-use changes may unpredictably affect water quality. As population and water demand increase, the volume of wastewater will also increase, which may then be discharged in proportions to the receiving water flow that could prevent some current domestic water sources to continue serving that beneficial use. Moreover, as demand for water grows, there may be demand as well to use some supplies—such as those originating from groundwater remediation sites—that would previously not have been approved for domestic use. For such supplies, drinking water standards alone may not be enough to determine quality, because such standards assume a basic purity of the water supply (see groundwater remediation/aquifer remediation). In addition, population growth may lead to increased demand for water-based recreation, which can degrade fisheries and wildlife habitat as well as drinking water supplies.

Monitoring and Assessment

Only a small percentage of California water bodies are regularly monitored and assessed for water quality or for the appropriate contaminants of concern. Once data is collected, it is too often not assessed or evaluated, and therefore not readily available for analysis. Much water quality data is collected on a project, rather than comprehensive, basis, and sampling program objectives, designs, methods, and quality assurance can vary greatly between projects. Even the SWRCB's biennial water quality assessment is limited by data availability, and notes as well another data problem: "healthy environments are less likely than troubled ones to be targeted for monitoring."

Fragmented Delivery and Regulation of Water Quality

Management and regulation of water quality in California is fragmented among at least eight State and federal agencies, with no one agency looking after water quality from source to tap. For example, the State and regional boards regulate ambient water quality, while DHS primarily regulates treatment and distribution of potable water. Further, surface water in California is mostly managed by DWR and the U.S. Bureau of Reclamation, while groundwater is usually not managed at all. Moreover, actually serving drinking water to Californians is an obligation of cities, water districts, and private water companies that were generally not formed in any comprehensive pattern.

Legacy Pollutants

Although abandoned mines, clear-cut forests, and many former industrial and commercial sites leave behind pollution problems (e.g. leaking underground storage tanks), what is often not left behind is a legally responsible or financially viable party to pay for cleanup. The State and federal governments and potentially responsible parties often wind up in extensive regulatory and legal proceedings determining legal and financial responsibility while hazardous waste sites remain.

Pollutant-by-Pollutant Water Quality Management

Federal law requires that the State regulate water quality on a programmatic, pollutant-by-pollutant basis, even though our rivers, lakes, and bays — and the aquatic organisms in them — are actually exposed to a mix of pollutants. Much has yet to be understood about the combined effects of chemicals, temperature, pH, transport, sunlight, and other factors. From the standpoint of ecosystem integrity, it is important to recognize that major threats may not be observed in obvious fish kills, but instead may arise subtly through sub-lethal changes in reproductive rates, gene structure, nervous system functions, or immune response. Such changes can over time affect species survival, and population and ecosystem structure.

Recommendations to Improve Pollution Prevention

1. In addition to regulating water quality on a pollutant-by-pollutant basis, water quality problems should be best managed using a watershed-based "source-to-tap"

approach. The State should adopt a strategy that integrates improvements in pollution prevention, water quality matching, and, for drinking water, treatment and distribution. For pollution prevention, such a strategy would build on urban and agricultural pollution prevention programs of SWRCB and RWQCBs, as well as DHS's Source Water Assessment Program.[4] The strategy would focus in particular on the prevention of nitrate pollution statewide.

2. In order to help implement the previous recommendation, the State should adequately fund basin plan triennial review and updates, for incorporation into the California Water Plan Update (pursuant to Section 13141 of the California Water Code). Per the CALFED Record of Decision, the State should complete the drinking water policy for the Delta and its tributaries, which as an amendment to the basin plan for the basins of the Sacramento and San Joaquin rivers, will be an additional tool for drinking water source protection.

3. State agencies with a regulatory, management, or scientific role in the California's water quality should take the lead in establishing an Interagency Water Quality Program to coordinate and integrate all federal, State, and local water quality monitoring and assessment programs, for surface water and groundwater. This program would include a focus on emerging, unregulated contaminants in order to provide an early warning system of future water quality problems, as well as identify trends in water quality. Such a program would also seek to standardize methods, especially for monitoring of emerging, unregulated contaminants, regularly monitor the quality of all waters of the state, and provide compatible data management that is accessible to a wide range of users. For drinking water supplies, this monitoring program should include a focus on outcomes-based monitoring, such as biomonitoring and waterborne disease outbreak surveillance.[5]

4. Regional, tribal, and local governments and agencies should establish drinking water source and wellhead protection programs to shield drinking water sources and groundwater recharge areas from contamination. These source protection programs should then be incorporated into local land use plans and policies. Such programs would encourage or regulate land-use activities that are protective of water quality, or, alternatively, discourage or restrict land uses or activities that threaten surface and groundwater quality. (See recharge area protection strategy.)

5. The State should prioritize grant funding for source water protection activities, including building institutional capacity for watershed planning.

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USEPA National Water Quality Inventory

DHS data Web site: www.dhs.ca.gov/ps/ddwem/chemicals/chemindex.htm

Interagency Coordinating Committee (for NPS Pollution Control)

Environmental Protection Indicators for California (EPIC)

[4] Such a strategy would be much like the "Equivalent Level of Public Health Protection (ELPH)" process of the CALFED Drinking Water Quality Program, and similar efforts recently established by the Massachusetts Water Resources Authority (for Boston), New York City, and the national governments of Canada and Australia. This strategy would also conform to the recommendations of the 2000 International Conference on Freshwater, held in Bonn, Germany.

[5] The proposed Interagency Water Quality Program would be modeled after the existing Interagency Ecological Program. The groundwater portion of this effort should be consistent with the recommendations of AB 599 (the Groundwater Quality Monitoring Act of 2001) and DWR's Bulletin 118 (California's Groundwater), while the surface water aspects should be coordinated with SWRCB's Surface Water Ambient Monitoring Program (SWAMP, AB 982).

Volume 2

Chapter 14 Precipitation Enhancement

Cloud seeding has been practiced continuously in California since the early 1950s. Most projects are along the central and southern Sierra Nevada with some in the Coast Ranges. (DWR photo)

Chapter 14 *Precipitation Enhancement*

Precipitation enhancement, commonly called "cloud seeding," artificially stimulates clouds to produce more rainfall or snowfall than they would naturally. Cloud seeding injects special substances into the clouds that enable snowflakes and raindrops to form more easily. Precipitation enhancement is the one form of weather modification done in California; hail suppression (reducing the formation of large, damaging hailstones) and fog dispersal (when fog is below freezing temperature) projects are conducted in other states.

Precipitation Enhancement in California

The first serious cloud seeding program in California began in 1948 on Bishop Creek in the Owens River basin for California Electric Power Co. Precipitation enhancement in the form of cloud seeding has been practiced continuously in several California river basins since the early 1950s. Most projects are along the central and southern Sierra Nevada with some in the coast ranges. The projects use silver iodide as the active cloud-seeding agent, supplemented by dry ice if aerial seeding is done. The silver iodide can be applied from ground generators or from airplanes. Occasionally other agents, such as liquid propane, have been used. In recent years, some projects have also been applying hygroscopic materials (substances that take up water from the air) as supplemental seeding agents. Figure 14-1 shows rain and snow enhancement programs for the 2002-2003 season.

Operators engaged in cloud seeding have found it beneficial to seed rain bands along the coast and orographic clouds over the mountains. The number of operating projects has tended to increase during droughts, up to 20 in 1991, but have leveled off to about 12 or 13 in recent years. The total area covered by these projects is about 13,000 square miles.

Policy statements by both the American Meteorological Society and the World Meteorological Organization support the effectiveness of winter orographic cloud seeding projects. The American Society of Civil Engineers has also shown interest with its Policy Statement No. 275 on Atmospheric Water Management in 2003 and a new report, ASCE/EWRI 42-04, "Standard Practice for the Design and Operation of Precipitation Enhancement Projects" in May 2004. This standards document will be a sequel to ASCE Manual No. 81, "Guidelines for Cloud Seeding to Augment Precipitation," published in 1995.

Benefits from Precipitation Enhancement

In California, all precipitation enhancement projects are intended to increase water supply or hydroelectric power. The amounts of water produced are difficult to determine, but estimates range from a 2 to 15 percent increase in annual precipitation or runoff. A National Research Council (NRC) report on weather modification (Box14-1) has limited material on winter orographic cloud seeding, such as practiced in California and other western states. However, the report does seem to concur that there is considerable evidence that weather modification does work, possibly up to a 10 percent increase. A detailed study by the Utah Department of Natural Resources in 2000 showed an average increase in April 1 snowpack water content ranging from 7 to 20 percent from a group of projects which had been operating from 9 to 22 years. The overall estimated annual runoff increase was about 250,000 acre-feet, or 13 percent for the study area. Actual increases in annual runoff are probably significantly less in California than in Utah. One conservative estimate is that the combined California precipitation enhancement projects generate 300,000 to 400,000 acre-feet annually, which would be an average of about a 4 percent increase in runoff.[1]

[1] DWR staff analysis (2004).

Figure 14-1 Rain and snow enhancement programs in California, 2002-2003 season

Project	Sponsor
1. Lake Almanor	Pacific Gas & Electric Co.
2. Tahoe-Truckee	Desert Research Institute
3. Upper American River	Sacramento Municipal Utility District
4. Upper Mokelumne River	Pacific Gas & Electric Co.
5. Carson and Walker Rivers	Desert Research Institute
6. Tuolumne River	Turlock and Modesto Irrigation Districts
7. San Joaquin River	Southern California Edison Co.
8. Eastern Sierra	City of Los Angeles
9. Kings River	Kings River Conservation District
10. Kaweah River	Kaweah Delta Water Conservation District
11. Kern River	North Kern Water Storage District
12. Santa Barbara County	Santa Barbara County
13. San Gabriel Mountains	Los Angeles County

There were 12 rain and snow enhancement programs for the 2002-03 season. Most projects are along the central and southern Sierra Nevada with some in the coast ranges. The total area covered by these projects is about 13,000 square miles.

Another 300,000 to 400,000 acre-feet per year may be available. Many of the best prospects are in the Sacramento River basin, in watersheds that are not seeded now. The Lahontan regions are already well covered by cloud seeding projects, except for the Susan River. With the exception of the upper Trinity River watershed, and perhaps the Russian River, there is little new potential in the North Coast region because not much extra rainfall could be captured due to limited storage capacity. There is also potential to increase water production by more effective seeding operations in existing projects.

Precipitation enhancement should not be viewed as a remedy for drought. Cloud seeding opportunities are generally fewer in dry years. It works better in combination with surface or groundwater storage to increase average supplies. In the very wet years, when sponsors already have enough water, cloud seeding operations are usually suspended.

Potential Costs

Costs for cloud seeding generally would be less than $20 per acre-foot per year. State law says that water gained from cloud seeding is treated the same as natural supply in regard to water rights.

It is estimated that about $3 million is being spent on operations. Realizing the additional 300,000 to 400,000 acre-feet of potential new supply could require about $7 million, which would be about $19 per acre-foot. An initial investment of an estimated $1.5 million to $2 million in planning and environmental studies would also be required. Over the next 25 years, precipitation enhancement costs are expected to total about $177 million.[2]

Major Issues for Precipitation Enhancement

Reliable Data

No complete and rigorous comprehensive study has been made of all California precipitation enhancement projects. Part of the reason is the difficulty in locating unaffected control basins for the standard target and nearby control area comparisons since wind variations would cause spillover into adjoining basins. Some studies of individual projects have been made in the past years on certain projects, such as the Kings River, which have shown increases in water.

Operational Precision

It is difficult to target seeding materials to the right place in the clouds at the right time. There is an incomplete understanding of how effective operators are in their targeting practices. Chemical tracer experiments have provided support for targeting practices.

Concern over Potential Impacts

Questions about potential unintended impacts from precipitation enhancement have been raised and addressed over the years. Common concerns relate to downwind effects (enhancing precipitation in one area at the expense of those downwind), long term toxic effects of silver, and added snow removal costs in mountain counties. The U.S. Bureau of Reclamation did extensive studies on these issues. The findings are reported in its Project Skywater programmatic environmental statement in 1977 and in its Sierra Cooperative Pilot Project EIS in 1981. The available evidence does not show that seeding clouds with silver iodide causes a decrease in downwind precipitation; in fact, at times some of the increase of the target area may extend up to 100 miles downwind (Ref. 1981 SCPP EIS). The potential for eventual toxic effects of silver has not been shown to be a problem. Silver and silver compounds have a rather low order of toxicity. According to the Bureau of Reclamation, the small amounts used in cloud seeding do not compare to industry emissions of 100 times as much into the atmosphere in many parts of the country or individual exposure from tooth fillings. Watershed concentrations would be extremely low because only small amounts of seeding agent are used. Accumulations in the soil, vegetation and surface runoff have not been large enough to measure above natural background. A 2004 study done for Snowy Hydro Limited in Australia has confirmed the earlier findings cited above. In regard to snow removal, little direct relationship to increased costs was found for small incremental changes in storm size because the amount of equipment and manpower to maintain the roadway is essentially unchanged. That is, the effort is practically the same to clear a road of 5.5 inches compared to 5 inches.

All operating projects have suspension criteria designed to stop cloud seeding any time there is flood threat. Moreover, the type of storms that produce large floods are naturally quite efficient in processing moisture into rain anyway. In such conditions, seeding is unlikely to make a difference.

Box 14-1 NRC Report on Weather Modification

In the fall of 2003, the National Research Council released a report entitled "Critical Issues in Weather Modification Research", which examined the status of the science underlying weather modification in the U. S. One conclusion widely reported by the press was that convincing scientific proof of the efficacy of weather modification was lacking and the authors proposed that a large sustained research program be developed to reduce the uncertainties of this technology. Progress in seeding agent formulation and targeting was noted, although there is need for more research on these aspects.

[2] Cost estimated = $0.2 billion, as follows: ($7 million/year for cloud seeding activities) x (25 years until 2030) + ($2 million for initial environmental studies) = $177 million.

Concern about Continuance of Hydroelectric Utility Seeding Operations

Four of the existing cloud seeding projects in California are sponsored by hydroelectric utilities. These four projects probably account for about a third of the estimated statewide water production by cloud seeding. There is some concern that if these power plants are sold, either as part of deregulation or for other reasons, new owners may not be interested in continuing cloud seeding. This would result in some loss in water supply for downstream users who have been indirectly benefiting from the added water. The State Public Utilities Commission is aware of this possibility and has tried to ensure, as a condition of transfer, that weather modification would continue.

Funding

Little federal research funding for weather modification has been available in the past 15 years. The Bureau of Reclamation had some funding in 2002 and 2003 in the Weather Damage Mitigation program. Desert Research Institute of Nevada did obtain a grant of $318,000 from this source early in 2003 to evaluate its seeding in the eastern Sierra.

Inadvertent Weather Modification

There is evidence that human activities such as biomass burning, transportation, and agricultural and industrial activities modify local and sometimes regional weather. The effects of aerosols on clouds and precipitation are complex. Recent studies by Ramanathan and Rosenfeld suggest suppressed precipitation formation in affected clouds due to pollution and dust. Some aerosols can enhance precipitation and some, especially the very fine aerosols in diesel smoke, can reduce precipitation. Much more research is needed to evaluate the air pollution effects on precipitation processes and the amount of impact as well as possible effects on cloud seeding programs. It is possible that some of the California cloud seeding projects have offset a potential loss in precipitation from air pollution, which may have obscured a more positive signal from the weather modification projects.

Recommendations to Increase Precipitation Enhancement

1. The State should support the continuation of current projects as well as the development of new projects and help in seeking research funds for both old and new projects.
2. DWR should collect base data and project sponsor evaluations of existing California and other western states precipitation enhancement projects, independently analyze them, and perform research on the effectiveness of this technology to supplement water supplies while minimizing negative impacts.
3. DWR should investigate the potential to augment Colorado River supply by cloud seeding, in cooperation with the Colorado River Board, the other Colorado River Basin States, and the U.S. Bureau of Reclamation.
4. DWR should support research on cloud physics and cloud modeling being done by the National Oceanic and Atmospheric Administration labs and academic institutions. With improvement, these models may become tools to further verify and test the effectiveness of cloud seeding activities.
5. DWR should support efforts by California weather modification project sponsors, such as that proposed in 2002-03 by Santa Barbara County Water Agency, to obtain federal research funds for local research experiments built upon their operating cloud seeding projects.

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Volume 2

Chapter 15 Recharge Areas Protection

Natural and constructed recharge areas must be protected to maintain groundwater quantity and quality. (DWR photo)

Chapter 15 *Recharge Areas Protection*

Recharge areas protection includes keeping groundwater recharge areas from being paved over or otherwise developed and guarding the recharge areas so they do not become contaminated. Protection of recharge areas, whether natural or man-made, is necessary if the quantity and quality of groundwater in the aquifer are to be maintained. Existing and potential recharge areas must be protected so that they remain functional and they are not contaminated with chemical or microbial constituents. Zoning can play a major role in recharge areas protection by amending land-use practices so that existing recharge sites are retained as recharge areas. See Box 15-1 for more discussion on recharge areas.

Protection of recharge areas is important, but protecting recharge areas by itself does not provide a supply of water. Recharge areas only function when aquifer storage capacity is available, and when regional and local governments and agencies work together to secure an adequate supply of good quality water to recharge the aquifer. Protecting existing and potential recharge areas allows them to serve as valuable components of a conjunctive management and groundwater storage strategy.

Other Volume 2 strategies related to Recharge Areas Protection are Urban Runoff Management (Chapter 21), Groundwater Remediation/ Aquifer Remediation (Chapter 11), and Conjunctive Management and Groundwater Storage (Chapter 4).

Recharge Areas in California

The first documented managed recharge program in California began in Los Angeles basin in 1889. Beginning in the early 1900s, water agencies operated recharge areas in the San Joaquin Valley. Additional recharge areas were established later in Southern California and San Francisco Bay Area. While a certain amount of recharge takes place in many areas, the areas that were chosen by water management agencies were those areas that met three conditions. First, the sediment is coarse enough to allow surface water to infiltrate at a higher rate than through finer sediments. Second, there is hydraulic continuity between the recharge area, the aquifer in which the groundwater is stored and transported, and the discharge area where wells are built to extract the groundwater. Third, a local agency had access to the land on which these first two conditions existed. Table 15-1 shows current recharge sites in California.

The size of existing recharge areas and the amount of groundwater that is recharged annually is substantial. The total amount of land devoted to spreading basins and off-stream and in-stream recharge probably exceeds 50 square miles. The actual area is difficult to determine, partially because many diversion ditches and creeks are active recharge sites during periods of the year. These active recharge areas and other areas should be protected for recharge purposes.

The Drinking Water Source Assessment Program (DWSAP) defines areas of protection for individual wells. The program can easily be expanded to include larger areas within the watershed. While the DWSAP requires assessment of these issues, the amendments to the Clean Water Act that require the assessment do not require implementation.

TreePeople, a citizens' organization, has been working with local government to retrofit playgrounds, school grounds, parking lots, and other parcels of land, to collect, treat, and funnel storm water to "dry" wells or other small scale infiltration facilities. Such wells are called Class V injection wells. While the goal of TreePeople is to reduce hardscapes and reduce runoff, the use of dry wells for disposal of the urban runoff can affect groundwater quality. To avoid contamination of the aquifer, certain best management practices are recommended. Those best management practices include low-flow basins for runoff from industrial areas and other areas that could

Agency	Type of Recharge Site
Arvin-Edison WSD	Off-stream
Berrenda Mesa WD	Off-stream
Calleguas MWD	Injection wells
City of Bakersfield	In-stream, off-stream
Coachella Valley WD	In-stream, off-stream
Flintridge-Cañada WD	Injection well
Fresno County FC&WCD	Off-stream, injection wells
Friant-Kern Water Users Authority	In-stream
Kern Water Bank	Off-stream
Los Angeles County DPW	In-stream, off-stream, injection wells
North Kern WSD	Off-stream
Orange County WD	In-stream, off-stream, injection wells
Pioneer (KCWA)	In-stream, off-stream
San Bernardino County WC&FCD	Off-stream
Santa Ana Watershed Project Auth.	Off-stream, injection wells
Santa Clara Valley WD	In-stream, off-stream
Semitropic WSD	Off-stream
United Water Conservation District	In-stream, off-stream

Table 15-1 Recharge sites in California

provide a high level of chemical contamination, pre-treatment for runoff, monitoring of water quality, evaluation of the data, and corrective action as necessary. All counties are required to regulate any type of water-related well, including injection wells, but the effectiveness of that program are uncertain at best. Class V injection wells are further regulated for groundwater quality purposes by the U.S. Environmental Protection Agency in accordance with the Underground Injection Control program authorized by the Safe Drinking Water Act.

Benefits from Protection of Recharge Areas

The primary benefit of protecting recharge areas is to make storage available as part of a sustainable and reliable water supply of good quality. The availability of a sustainable and reliable water supply may lessen the need to purchase alternative water supplies at greater expense. Protection of recharge areas does not make a water supply available; a supply of water to recharge the aquifer depends on coordination of regional and local governments and agencies.

Additional benefits of recharging groundwater include some removal of microbes and chemicals while the water moves through the unsaturated zone to the saturated zone, an increase in the amount of groundwater in storage that can later be extracted for local use or for export, and in some cases, use of the aquifer itself as the conveyance system from the recharge area to the point of extraction and use. In some cities, recharge basins are combined with flood control basins to reduce the amount of urban runoff.

Potential Costs

Some of the costs that may be associated with protecting recharge areas are:

- Purchase or lease price of the land that is to be used for a recharge area.
- Design and construction of facilities
- Land that is reserved for recharge areas cannot be used for other purposes that might provide a significant income for the landowner and tax revenues for the government
- If a local government agency owns the land, there is no tax income for the county

By not protecting recharge areas, water supply can be lost. The growth of urban areas, with roads, freeways, parking lots, and large warehouse type buildings, means that many areas no longer allow runoff to infiltrate into the ground. Instead, the runoff flows rapidly into streams which peak more quickly and at higher flow rates than before the urban facilities were built. This runoff is lost to groundwater recharge and may require the expense of other facilities to provide a substitute for that lost recharge. In some urban areas, injection wells have been built to take the place of recharge that was lost to urban development. Injection wells are expensive and are not always successful, but they may be cost effective in the face of the high cost of urban land in many cities.

Many potentially contaminating activities have routinely been allowed in recharge areas and contaminants have been carried into the aquifers. Remediation of these areas can take decades, costs millions or billions of dollars, and will never remove the contaminant completely from the aquifer. In such cases, the extracted groundwater must be treated at the wellhead at significant expense before it is suitable for potable and other uses.

A lack of protection of recharge areas could decrease the availability of usable groundwater. Recent studies by the U.S. Geological Survey show contaminants present in recharge areas for aquifers in the Los Angeles area. In 10, 20, or 40 years, those contaminants will have been transported into the aquifer and the groundwater may require treatment before it can be used, thereby increasing the cost of water to the users. Protection of recharge areas now will help to prevent costs

Box 15-1 Recharge Areas

Recharge areas are those areas that provide the primary means of replenishing the groundwater that is stored in an aquifer. In simple terms, a groundwater system consists of three component parts—recharge areas, storage capacity called an aquifer, and discharge areas or points. If recharge areas cease functioning properly, there is no water to store in, or remove from, the aquifer. Under natural conditions sandy areas that lie over alluvial aquifers provide good recharge areas for that aquifer.

Natural recharge takes place without interference or assistance from people. Artificial, intentional, or managed recharge is additional recharge that takes place with the assistance of people. Artificial, intentional, or managed recharge can take place in areas where natural recharge occurs (stream channels or alluvial fans) by increasing flow volume and decreasing flow velocity. In addition, this recharge can take place in structures built specifically for increasing recharge. These structures are called recharge basins, spreading basins or replenishment basins or areas. The goal of all managed recharge is to increase the rate of infiltration or percolation of surface water into the subsurface, and ultimately, into the saturated zone in the aquifer. Some areas that would provide good rates of recharge have been paved over or built upon and are no longer available to recharge the aquifer.

The three types of recharge that are possible are in-stream, off-stream, and injection wells. In-stream recharge allows water to percolate through the stream bed itself. Off-stream recharge uses suitable sites outside the streambed. In some operations, the water must be pumped some distance from its source to the off-stream recharge area. Injection wells are used at locations where the cost of large tracts of land would be prohibitive.

Each method has pros and cons. In-stream and off-stream spreading basins are eventually clogged with the suspended material carried in the surface water to the point that the rate of recharge declines considerably, making the basin much less effective. Those fines must somehow be removed. In urban areas the cost of land necessary for spreading basins may be prohibitive. Injection wells are expensive to build and are also subject to clogging unless the water is treated and turbidity is nil.

Protection of recharge areas consists of two components: (1) preventing the areas from being covered by urban infrastructure, which renders the land unusable for recharge; and, (2) preventing chemical or microbial contamination that would require expensive treatment before the water could be used for potable, agricultural, or industrial purposes from escalating astronomically in the future. Because of the low velocity of groundwater movement through the aquifer, contamination that occurs today may not arrive at down-gradient wells for 10 years or longer. If we protect recharge areas by retaining those areas for recharge and by preventing contamination today, we are reducing future costs.

Major Issues Relating to Protection of Recharge Areas

Data and Standards

There is a lack of standardized guidelines for pre-treatment of the recharge water, including recycled water. There is also a lack of monitoring wells to provide data on changes in groundwater quality that may be caused by recharge. Inspection programs are generally not adequately funded and staffed to locate, inspect, design protection measures, and destroy abandoned wells that provide vertical conduits for contamination of aquifers.

Zoning

Local governments often lack a clear understanding of recharge areas and how to protect those areas from development or contamination. Land use zoning does not always recognize the need for recharge area protection for water quantity and water quality.

Vector and Odor Issues

Standing water in recharge ponds or spreading basins is an attraction for mosquitoes, dragonflies, and other insects whose egg, larval, and pupal stages mature underwater. Dragonflies eat insects they catch on the fly, but mosquitoes can be vectors for a number of serious or deadly diseases. Existing recharge programs use large numbers of "mosquito" fish which feed on the mosquito larvae in the water. Odors can be generated by growth and decay of algae and other water-borne vegetation. Both vectors and odors must be addressed in any recharge program that involves standing water.

Potential Impacts

Protection of recharge areas can remove land from availability for other uses.

Recommendations to Help Promote Protection of Recharge Areas

The State can help promote additional protection of recharge areas by acting on the following recommendations:

1. Increase State funding for proposals to identify and protect recharge areas including incentives for the location and proper destruction of abandoned water wells, monitoring wells, cathodic protection wells and other wells that could become vertical conduits for contamination of the aquifer. Provide funding and staff for Department of Health Services to initiate a program that would provide guidance and funding for local governments and agencies to implement source water protection measures that are logical outgrowths of the Drinking Water Source Assessment Program.
2. Expand research into surface spreading as a means of groundwater recharge and the fate of chemicals and microbes contained in the recharge water.
3. Develop a statewide program to identify potential recharge areas throughout the state and provide that information to city and county governments.
4. Amend State law to prohibit local decision-makers from developing land for other purposes until it is known if that land is needed for recharge as a part of the local agency's groundwater management program.
5. Engage the public in an active dialogue using a value-based decision-making model in planning land use decisions that involve recharge areas. Adopt a State-sponsored media campaign to increase public awareness and knowledge of groundwater and the importance of recharge areas.
6. Establish a "Water" element in the General Plan process that specifically requires a discussion by local government of the cost and values of protecting recharge areas versus the cost of non-protection. Eminent domain should not be allowed to convert potential recharge areas to other uses.[1]
7. Ensure that federal and State programs regulating subsurface disposal in accordance with the Safe Drinking Water Act's Underground Injection Control program and the California Clean Water Act's waste discharge requirements are fully funded and staffed.

[1] For a fuller discussion of the proposed water element in a General Plan, please refer to "Planning for a Demanding Water Future: The Legal Requirements for Long-Term Land Use and Water Planning in California, and an Analysis of a Water Element in the General Plan as a Means to Improve the Connection," found in Volume 4.

8. Require local governments to provide protection of recharge areas for aquifers that have been identified as "sole source aquifers" pursuant to the Safe Drinking Water Act of 1974 (P.L. 93-523) and Amendments.
9. Develop educational programs for public works officials and other officials of local agencies and governments that will allow them to develop programs that realistically deal with the interaction of groundwater, surface water, storm water, other surface flows, and the affect of contaminants in surface flows on contaminant levels in the aquifers.
10. Require that source water protection plans include an element that addresses recharge areas if groundwater is a part of the supply.
11. Convene a statewide panel to recommend changes to public schools and higher education curricula relating to groundwater. Encourage an integrated academic program on one or more campuses for protection of groundwater quantity and quality and why recharge areas are critical components.
12. Develop a uniform method for analyzing the economic benefits and cost of recharge areas and provide guidance and assistance for economic feasibility analyses that could be used by project planners and funding agencies to assess recharge areas as compared with long-term reduction of water supplies, wellhead treatment, or injection wells.
13. Develop a signage program, modeled on such programs in other states, to notify people that they are entering an area of critical recharge for the groundwater they use daily, and that improper disposal of wastes can contaminate their drinking water.

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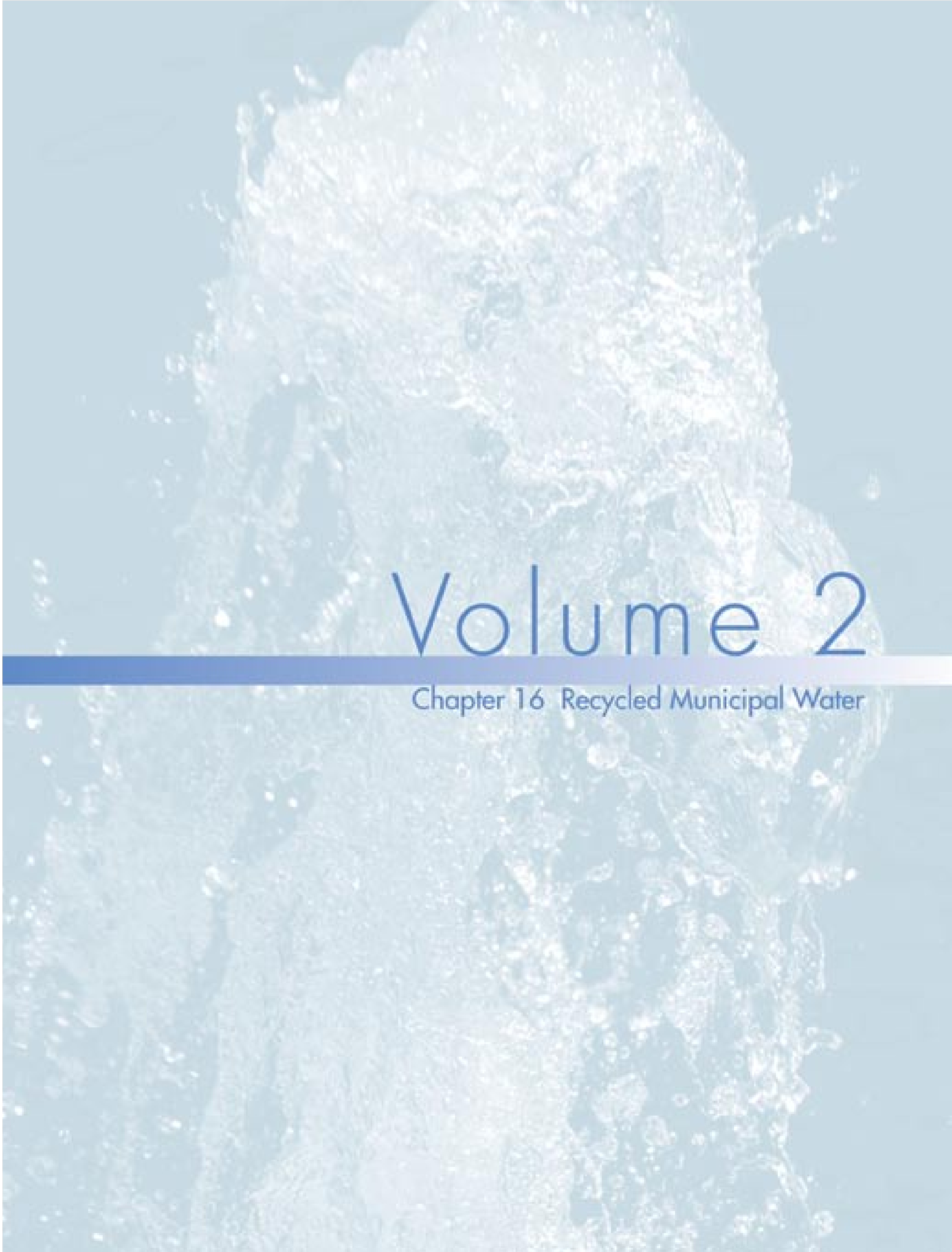


Volume 2

Chapter 16 Recycled Municipal Water

Recommendations from a 40-member Recycled Water Task Force would improve the way projects are planned, increase State and federal financial support for research and project construction, improve the regulatory framework, and advance the use of recycled water.

Chapter 16 *Recycled Municipal Water*

Water recycling, also known as reclamation or reuse, is an umbrella term encompassing the process of treating wastewater, storing, distributing, and using the recycled water. Recycled water is defined in the California Water Code to mean "water which, as a result of treatment of waste, is suitable for a direct beneficial use or a controlled use that would not otherwise occur."

The treatment and use of municipal wastewater for golf course irrigation is an example of water recycling. Higher levels of treatment can make municipal wastewater reusable for school yards, residential landscape and park irrigation, industrial uses or even uses within office and institutional buildings for toilet flushing.

The following discussion of recycled water focuses on treated municipal wastewater. This is wastewater of domestic origin, but includes wastewater of commercial, industrial and institutional origins if such wastewater is mixed with domestic wastewater before treatment. Many industries recycle and reuse their own wastewater. However, because of a lack of data, recycling of non-domestic wastewater is not included in the recycling-quantity estimates below.

Recycled Water Use in California

Californians have used recycled water since the late 1800s and public health protections have been in effect since the early part of the 1900s. Recycled water use has dramatically increased in the past several decades as water agencies needed to supplement their water supplies. Today, California's water agencies recycle about 500,000 acre-feet of wastewater annually, almost three times more than in 1970.

Noting the importance of water recycling to our state, a 40-member Recycled Water Task Force was established pursuant to Assembly Bill No. 331(Goldberg, Chapter 590, Statutes of 2001). The Task Force identified opportunities for, and constraints and impediments to, increasing the use of recycled water in California. Over the course of nearly 14 months, the Task Force conducted intensive study in collaboration with many other experts, the public, and State staff to develop recommendations (see Box 16-1 on following pages) for actions at many levels. The recommendations are not restricted to legislative actions or statutory changes. Many can be implemented by State or local agencies without further legislative authorization or mandate.

The Task Force recommendations, if implemented, would significantly:

- Improve the way projects are planned
- Increase State and federal financial support for research and project construction
- Improve the regulatory framework
- Advance the use of recycled water as a valuable resource that would significantly mitigate growing water demands as called for by the California Water Code, Sections 13500 et seq.

Progress has begun on several of the Task Force recommendations. For example, the SWRCB issued an Executive Memorandum to Regional Board Executive Officers on February 24, 2004, setting a new framework for regulating of incidental runoff associated with recycled water use. AB 334 (Goldberg, Chapter 172, Statutes of 2003) gives communities additional flexibility to regulate water softeners as a source-control measure.

Potential Benefits from Water Recycling

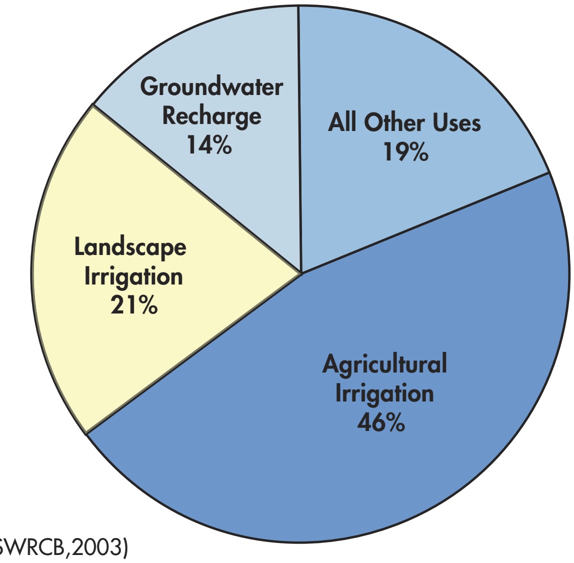
The primary benefit of water recycling is augmenting water supply. Rather than discharging and losing the water, recycled water can be reused as a new water supply. Using recycled water for irrigation can spare high quality potable water used for irrigation, making more potable water supply available. There is a potential of about 0.9 million to 1.4 million acre-feet annually of additional water supply from recycled water by the year 2030.

When looking at California's overall water supply, recycling provides new water for the state only in areas where waste-water is discharged to the ocean or to salt sink. Recycling in other areas may provide new water for the water agency, but does not necessarily add to the state's water supplies. In these locations, discharged wastewater in interior California mixes with other water and becomes source water for downstream water users.

For many communities, an investment in recycled water could also provide other benefits:

1. Provide more reliable local sources of water, nutrients, and organic matter for agricultural soil conditioning and reduction in fertilizer use
2. Reduce the discharge of pollutants to water bodies, beyond levels prescribed by regulations, and allow more natural treatment by land application
3. Provide a more secure water supply during drought periods
4. Provide economic benefits resulting from a more reliable water supply
5. Improve groundwater and surface water quality and contribute to wetland and marsh enhancement
6. Provide energy savings; the use of recycled water as a local source offsets the need for energy-intensive imported water

Figure 6-1 Where recycled water is used in California



(SWRCB,2003)

Recycled water use has dramatically increased in the past several decades for irrigated agriculture and landscapes, groundwater recharge and other uses. Today, California's water agencies recycle about 500,000 acre-feet of wastewater annually, almost three times more than in 1970.

Potential Costs of Recycled Water

The estimated capital cost for the range of potential recycling (from previous section) by 2030 is about $6 billion to $9 billion.[1] The actual cost will depend on the quality of the wastewater, the treatment level to meet recycled water intended use, and the availability of a distribution network. Uses, such as irrigation near the treatment plant, will benefit from lower treatment and distribution costs. Irrigation of a wide array of agriculture and landscape crops can even benefit from the nutrients present in the recycled water by lowering the need for applied fertilizer. However, the use of recycled water for irrigation without adequate soil and water management may cause accumulation of salts or specific ions in soil and groundwater. Some uses, such as an industrial process farther away from the treatment plant, may need to pay higher costs for treatment and distribution. Given the wide range of local conditions that can affect costs, the majority of applications would cost between $300 and $1,300 per acre-foot of recycled water. Costs outside this range are plausible depending on local conditions. Uses that require higher water quality and have higher public health concerns will have higher costs.

Major Issues Facing More Recycled Water Use

Affordability

The cost of recycled water, relative to other water sources, will influence how much recycled water is produced for each region. The costs are dependent on the availability of treatable water, demand for treated water, the quality of the source as well as the product water, the type of the intended beneficial use, and the proximity of recycled water facilities to the end users. In addition, the need for disposal brine lines is considered a major issue for some inland agencies. The lack of adequate local funding to plan feasible recycled water projects can slow the construction of new projects. Public funding as well as incentive measures can help advance water recycling

[1] Water Recycling 2030; Recycled Water Task Force (2003).

Box 16-1 California Recycled Water Task Force Recommendations Summary (2003)

Funding for Water Recycling Projects. State funding for water reuse/recycling facilities and infrastructure should be increased beyond Proposition 50 and other current sources. The California Water Commission in collaboration with DWR and SWRCB should seek federal cost sharing legislation for water recycling.

Funding Coordination. A revised funding procedure should be developed to provide local agencies with assistance in potential State and federal funding opportunities and a Water Recycling Coordination Committee should be established to work with funding agencies.

Department of Water Resources Technical Assistance. Funding sources should be expanded to include sustainable State funding for DWR's technical assistance and research, including flexibility to work on local and regional planning, emerging issues, and new technology.

Research Funding. The State should expand funding sources to include sustainable State funding for research on recycled water issues.

Regional Planning Criterion. State funding agencies should make better use of existing regional planning studies to determine the funding priority of projects. This process would not exclude projects from funding where regional plans do not exist.

Funding Information Outreach. Funding agencies should publicize funding availability through workshops, conferences, and the Internet.

Community Value-Based Decision-Making Model for Project Planning. Local agencies should engage the public in an active dialogue and participation using a community value-based decision-making model in planning water recycling projects.

State-Sponsored Media Campaign. The State should develop a water issues information program, including water recycling, for radio, television, print, and other media.

Educational Curriculum. The State should develop comprehensive education curricula for public schools; and institutions of higher education should incorporate recycled water education into their curricula.

University Academic Program for Water Recycling. The State should encourage an integrated academic program on one or more campuses for water reuse research and education, such as through State research funding.

Statewide Science-Based Panel on Indirect Potable Reuse. As required by AB 331, the Task Force reviewed the 1996 report of the California Indirect Potable Reuse Committee and other related advisory panel reports and concluded that reconvening this committee would not be worthwhile at this time. However, it is recommended to convene a new statewide independent review panel on indirect potable reuse to summarize existing and on-going scientific research and address public health and safety as well as other concerns such as environmental justice, economic issues and public awareness.

Leadership Support for Water Recycling. State government should take a leadership role in encouraging recycled water use and improve consistency of policy within branches of State government and local agencies should create well-defined recycled water ordinances and enforce them.

DHS Guidance on Cross-connection Control. DHS should prepare guidance that would clarify the intent and applicability of Title 22, Article 5 of the California Code of Regulations pertaining to dual plumbed systems and amend this article to be consistent with requirements included in a California version of Appendix J that the Task Force is recommending to be adopted.

Health and Safety Regulation. DHS should involve stakeholders in a review of various factors to identify any needs for enhancing existing local and State health regulation associated with the use of recycled water.

Stakeholder Review of Proposed Cross-Connection Control Regulations. Stakeholders are encouraged to review Department of Health Services draft changes to Title 17 of the Code of Regulations pertaining to cross-connections between potable and nonpotable water systems.

continued

projects that provide local, regional and statewide benefits. The cost of recycled water can influence water markets, especially if recycled water is available for transfer.

Water Quality

The quality of the recycled water will affect its usage. Public acceptance of recycled water use depends on confidence in the safety of its use. Four water quality factors are of particular concern: (1) microbiological quality, (2) salinity, (3) presence of heavy metals, and (4) the concentration of stable organic and inorganic substances or emerging contaminants originating from various pharmaceuticals and personal care products, household chemicals and detergents, agricultural fertilizers, pesticides, fungicides, animal growth hormones, and many other sources. The salinity of recycled water can limit its usefulness for some applications such as salt sensitive landscaping, golf courses, and agriculture. Each use of water generally adds salt to the water. In particular, the use of water softeners adds salt to the water. Also, water conservation can further concentrate salts. Hence, the resulting wastewater, that is high in salts, would be more difficult and expensive to recycle. There is generally a limit to how many times water can be recycled unless a more expensive treatment technology, such as reverse osmosis, is used to remove the salts (see the Desalination strategy).

Box 16-1 continued from previous page

Cross-Connection Risk Assessment. DHS should support a thorough assessment of the risk associated with cross-connections between disinfected tertiary recycled water and potable water.

Uniform Plumbing Code Appendix J. The State should revise Appendix J of the Uniform Plumbing Code, which addresses plumbing within buildings with both potable and recycled water systems, and adopt a California version that will be enforceable in the state.

Recycled Water Symbol Code Change. The Department of Housing and Community Development should submit a code change to remove the requirement for the skull and crossbones symbol in Sections 601.2.2 and 601.2.3 of the California Plumbing Code.

Incidental Runoff. The State should investigate, within the current legal framework, alternative approaches to achieve more consistent and less burdensome regulatory mechanisms affecting incidental runoff of recycled water from use sites.

Source Control. Local agencies should maintain strong source control programs and increase public awareness of their importance in reducing pollution and ensuring a safe recycled water supply.

Water Softeners. The Legislature should amend the Health and Safety Code Sections 116775 through 116795 to reduce the restrictions on local ability to impose bans on or more stringent standards for residential water softeners. Within the current legal provisions on water softeners, local agencies should consider publicity campaigns to educate consumers regarding the impact of self-regenerative water softeners.

Uniform Interpretation of State Standards. The State should create uniform interpretation of State standards in State and local regulatory programs by taking specific steps recommended by the Task Force.

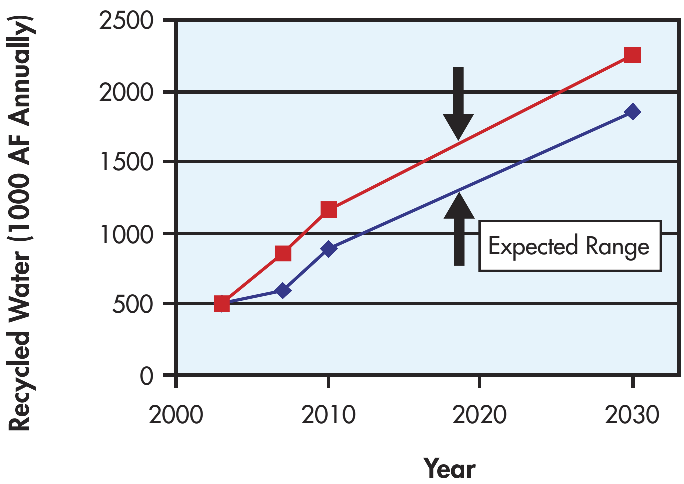
Permitting Procedures. Various measures should be conducted to improve the administration and compliance with local and State permits. State and local tax incentives should be provided to recycled water users to help offset the permitting and reporting costs associated with the use of recycled water.

Uniform Analytical Method for Economic Analyses. A uniform and economically valid procedural framework should be developed to determine the economic benefits and costs of water recycling projects for use by local, State, and federal agencies.

Project Performance Analysis. Resources should be provided to funding agencies to perform comprehensive analysis of the performance of existing recycled water projects in terms of costs and benefits and recycled water deliveries.

Economic Analyses. Local agencies are encouraged to perform economic analyses in addition to financial analyses for water recycling projects and State and federal agencies should require economic and financial feasibility as two criteria in their funding programs.

Figure 16-2 Range of potential water recycling (Water Recycling 2030 Report)



When looking at California's water supply, recycling provides additional statewide supply only in areas where wastewater is discharged to the ocean or to salt sink. Recycling in other areas may provide water supply benefits for the water agency, but does not necessarily add to the state's water supplies.

Public Acceptance

Public perception and acceptance of some recycled water uses currently limits its application. In some areas, public concerns about potential health issues have limited the use of recycled water for indirect potable purposes such as groundwater recharge and replenishment of surface storage, and even for irrigation of parks and school yards.

Potential Impacts

Areas in interior California that discharge their wastewater to streams, rivers, or the groundwater contribute to downstream flows. Recycling water would remove this source of water and potentially affect downstream water users including the environment. In some instances, recycling is discouraged when dischargers are required to maintain a certain flow in the stream for downstream users.

Recommendations to Increase Recycled Water Usage

1. State and local agencies and various stakeholders should actively follow up with the implementation of the Recycled Water Task Force recommendations (see Box 16-1) as they constitute a culmination of intensive study and consultation by a statewide panel of experts drawing upon the experience of many agencies. Such recommendations provide advice that can be used as a toolbox for communities to improve their planning of recycled water projects. (Implementing parties: State and local agencies and various stakeholders)
2. Funding should be increased beyond Proposition 50 and other sources toward sustainable technical assistance and outreach, advanced research on recycled water issues, and adequate water reuse/recycling infrastructure and facilities. (Implementing parties: federal, State, and local agencies)
3. The State should encourage an academic program on one or more campuses for water reuse research and education; develop education curricula for public schools; and encourage institutions of higher education to incorporate recycled water education into their curricula. (Implementing parties: State and academic institutions)
4. Agencies should engage the public in an active dialogue and participation using a community value-based decision-making model (determining what a community values, then making decisions based on that information) in planning water recycling projects. (Implementing parties: State and local agencies)
5. State should create uniform interpretation of State standards in State and local regulatory programs and clarify regulations pertaining to water recycling including: health regulations, permitting procedures, cross-connection control and dual plumbed systems. (Implementing parties: State agencies)

Selected References

Water Recycling 2030, California Recycled Water Task Force Report, 2003.

SWRCB, California Municipal Wastewater Reclamation Survey, 2003.

Water Recycling 2000, California's Plan for the Future. State Water Conservation Coalition, Reclamation/Reuse Task Force and the Bay Delta Reclamation Sub-Work Group, 1991.

Southern California Comprehensive Water Reclamation and Reuse Study, Phase II. Final Report (Draft), 2000.

Other reports such as DWR Water Recycling Survey, 1993; California Water Plan Update 1998.

Volume 2

Chapter 17 Surface Storage – CALFED

The CALFED Bay-Delta Program recognizes that its plan must include the means for more fully integrating California's water supply system to provide more reliable water supplies and to meet competing needs. The San Luis Reservoir is an example of offstream storage. (DWR photo)

Chapter 17 *Surface Storage – CALFED*[1]

The CALFED Record of Decision (2000) identified five potential surface storage reservoirs that are being investigated by the California Department of Water Resources, U.S. Bureau of Reclamation, and local water interests. Building one or more of the reservoirs would be part of CALFED's long-term comprehensive plan to restore ecological health and improve water management of the Bay-Delta. The five surface storage investigations are:

- Shasta Lake Water Resources Investigation (SLWRI)
- In-Delta Storage Project (IDSP)
- Upper San Joaquin River Basin Storage Investigation (USJRBSI)
- North-of-the-Delta Offstream Storage (NODOS)
- Los Vaqueros Reservoir Expansion (LVE)

In one of the most ambitious integrated water management plans in the nation, the CALFED Bay-Delta Program set forth objectives and actions to protect water quality and at-risk species, restore habitat in the San Francisco Bay-Sacramento-San Joaquin River Delta and continue to meet the water needs of farms and cities. CALFED recognized early on that its plan must include the means for more fully integrating California's water supply system to provide more reliable water supplies and to meet competing needs. More storage is crucial to successfully meeting those needs.

The five investigations are being completed under the direction provided by the CALFED Record of Decision (ROD) and the California Bay-Delta Authority (CBDA). The ROD includes a number of implementation commitments and solution principles to guide potential project implementation. For example, a fundamental principle is that costs should, to the extent possible, be paid by the beneficiaries of the program actions. CALFED has also provided a forum for independent scientific review of important project-related issues through development of a Science Program with expert panels. In addition, the CBDA agencies have committed to science-based adaptive management that would allow their facilities operations to be modified as understanding of issues improve or new issues are identified.

Originally, a CALFED interagency team began with an inventory of 52 potential reservoir locations and screened those to 12 locations that appeared to contribute to CALFED goals and satisfy solution principles, objectives, and policies. For example, potential reservoirs smaller than 200,000 acre-feet of storage were considered too small to materially contribute to the program. In addition, CALFED policy focused on off-stream reservoirs, but also considered expansion of existing on-stream reservoirs. The five storage investigations identified in the ROD appeared to be more promising in their ability to contribute to ecosystem, water quality, flood control and water supply objectives.

The surface storage regional/local strategy gives a broader background of surface storage in California that may also be helpful to the reader. Details and project-specific descriptions of the investigations can be found in the April 2005 CALFED Bay-Delta Surface Storage Investigations Progress Report that is included in Volume 4, Reference Guide.

Current Status of CALFED Surface Storage

Planning for the five CALFED-directed investigations has made varying levels of progress. Current timelines have targeted 2006–2009 for completing the planning documents. Essen-

[1] The primary source of information for this strategy narrative is the DWR and U.S. Bureau of Reclamation report entitled, "CALFED Bay-Delta Surface Storage Investigation" April, 2005, included in Volume 4, Reference Guide.

tially, the planning consists of project formulation, environmental documentation and engineering design. As relevant and useful information becomes available, both stakeholders and the public are notified to ensure that a broad array of input and response are incorporated into the planning activities and documentation. More specifically, as project costs, environmental effects, and benefits are compiled, regulators, the public, and ultimately decision-makers will be asked to respond to the evaluations and conclusions (see Box 17-1).

The CALFED surface storage investigations have reached a critical milestone. With input from stakeholders and assistance from local agencies, USBR and DWR have completed preliminary environmental impact studies and conceptual modeling scenarios based on general operational objectives. Now each investigation must move toward a specific set of operational objectives to formulate detailed alternatives that can be used in decision-making processes. Future efforts now hinge on the willingness of interested parties and stakeholders to participate and shape the alternative formulations that will be used to make decisions on these projects. Evaluations to date demonstrate that the surface storage projects have the potential to provide both broad public benefits and local/regional benefits.

Potential Benefits from CALFED Surface Storage

CALFED noted that perhaps the greatest benefit of new surface storage would be the operational flexibility that storage adds to today's constrained system (See Box 17-2). The Bay-Delta system provides water for a wide range of needs, including instream flows for aquatic species, riparian habitat, wetlands, as well as benefits to municipal, industrial, and agricultural users. These often-competing demands have restricted the operational flexibility of the SWP and CVP systems and consequently negatively impacted the quantity, quality, and timing of deliveries. The inflexibility and resulting consequences are then passed along to water users that are partially or wholly dependent on the operations or deliveries of the CVP and SWP systems. By storing additional water, new surface storage can contribute to improved operational flexibility in the SWP and CVP systems and associated users for the enhanced statewide water resources benefits described below.

Each of the five surface storage reservoirs could be used to improve water supply reliability. The surface storage projects could also improve source water quality directly or facilitate blending of water from different sources. New surface storage can help provide water for the CALFED Environmental Water Account and other environmental needs including ecosystem restoration actions also identified by the CALFED Program. New surface storage can also help reduce the risk associated with potential future climate change by mitigating the effects of a relatively smaller seasonal snowpack storage capacity. Implementation of individual surface storage reservoirs could augment average annual water deliveries by anywhere from a negligible amount to over 400,000 acre-feet (according to initial operations simulations), depending on the mix of benefits selected by participating agencies and operational considerations (DWR and USBR, April 2005).

The total amount of potential water supply improvements from implementation of all five surface storage projects is unknown since operations with multiple new reservoirs have not yet been modeled. However, initial model simulations show that the potential reservoirs could provide a wide range of type and geographic scope of benefits including agricultural uses, CALFED Environmental Water Account and Environmental Water Program and water supply for refuges. Additional potential benefits include urban uses, improvement of Delta water quality for the ecosystem as well as Delta users and exporters, improvement of streamflows during times critical for fisheries and other ecosystem processes, flexibility for changing the timing of existing diversions to protect fisheries, and other water management purposes.

Box 17-1 Ongoing Surface Storage Investigations

The planning process for surface storage is both comprehensive and demanding. The CALFED surface storage investigations have been developed to comply with both the state and federal environmental laws, which require extensive documentation and public involvement. In addition, implementation of any one surface storage project would likely require more than 30 regulatory permits and compliances. Both the environmental laws and the permits and compliances will allow the public to participate in a more comprehensive and informed manner and on specific issues at the appropriate time. For more information related to public involvement in the investigations, visit www.storage.water.ca.gov/index.cfm

Other strategies can be more effective with additional storage. For example, water transfers can be more easily accommodated if water can be stored temporarily and then released from an upstream location at appropriate times and the receiving areas have capacity to store the transferred water. In addition, surface storage can improve the effectiveness of conjunctive management strategies by more effectively capturing runoff that can ultimately be stored in groundwater basins.

Potential Costs of CALFED Surface Storage

New feasibility engineering cost estimates are in various stages of development for each of the five surface storage investigations (DWR and USBR, April 2005). Costs will depend on project selected objectives and configurations. The estimated capital cost for developing the individual surface storage projects identified in the ROD could range from $180 million for the smallest Shasta Lake Expansion, to $2.4 billion for Sites Reservoir with the most extensive conveyance facilities; the least expensive configuration of Sites Reservoir could be about half as much as the most expensive. These costs do not include anticipated annual costs such as operations and maintenance, power, or costs associated with the use of existing facilities. As the investigations continue to move forward, more complete descriptions of costs and more specific allocation of benefits will allow an economic evaluation where costs can be assigned to specific beneficiaries and benefits. Implementation of any of the five potential surface storage projects would likely include some State and federal public funding to pay for broad public benefits.

Major Issues Facing CALFED Surface Storage

Funding

Sufficient and stable State and federal funding are critical to successful completion of the feasibility and environmental studies for the five projects. California's Proposition 50 provided State funding for surface storage investigations. In October 2004, the president reauthorized the CALFED Bay-Delta Program. PL108-361 reaffirms federal feasibility study authorization for four of the five storage investigations (SLWRI, NODOS, LVE, and USJRBSI). DWR, USBR and CBDA recently estimated funding necessary to complete the five investigations at $64.3 million. An estimated $29.2 million remains available from Proposition 50 bond proceeds to support surface storage investigations. The federal budget for this fiscal year and the president's proposed budget for next year amount to approximately $13.5 million, leaving an unmet need of $21.6 million. Any future federal appropriations will reduce this need further. Other efforts are underway that are also likely to help facilitate decisions regarding future funding for the surface storage investigations.

DWR has prioritized its work efforts to focus resources on identifying the most viable projects and project tasks. DWR and USBR will work cooperatively to evaluate projects using information associated with federal planning studies and reports. In addition, DWR and USBR are working with stakeholders to identify which projects have the greatest local interest and possible willingness to pay for project costs. The

Box 17-2 Los Vaqueros, Olivenhain and Diamond Valley Reservoirs

Three locally developed reservoirs that have been completed in the past seven years, Los Vaqueros in Northern California and Olivenhain and Diamond Valley in Southern California, are examples of offstream surface storage. The use or objectives of these reservoirs focused on benefits other than the traditional energy generation, flood control, and water supply. The primary benefits of these new reservoirs are related to water quality, system flexibility, and system reliability against catastrophic events and droughts. More specifically, water supply augmentation is not a primary objective of these reservoirs.

Los Vaqueros, Olivenhain, and Diamond Valley also help illustrate a potential misunderstanding of benefits in applying simplified cost calculations where yield is divided by total cost, generating a cost per acre-foot. This approach would evaluate storage projects based on cost per acre-foot of water supply improvement only. Since these projects were constructed for other benefits, the "yields" of these reservoirs are incidental. Consequently, a simplified cost per acre-foot evaluation would generate almost infinite unit cost. Similarly, application of a simplified cost allocation for the CALFED surface storage investigations is not appropriate, since these projects focus on operational flexibility, water quality, ecosystem restoration or other nontraditional benefits, in addition to water supply improvement.

CALFED surface investigations will then use results of these evaluations to develop partnerships with stakeholders to advance alternatives development and plan formulation. If partnerships are not formed (demonstrating lack of interest in advancing a project) and/or the outcome of technical and economic studies indicate any of the five projects are not feasible, the State may decide to defer future studies of specific projects. Given the estimated funding shortfall, one or more of the studies, of lesser determined priority, may have to be delayed or even terminated unless they are provided specific financial support.

Common Assumptions Effort

DWR, USBR, and CBDA initiated the Common Assumptions process to develop consistency and improve efficiency among the surface storage investigations. While each of the investigations addresses a unique purpose to meet different combinations of water supply and water quality needs, all of the surface storage investigations share some common requirements including completing planning reports and feasibility studies and the associated alternatives analyses to comply with the California Environmental Quality Act (CEQA), National Environmental Protection Act, and Clean Water Act Section 404 requirements.

The Common Assumptions teams have also been developing a set of common tools and consistency protocols among the surface storage investigations. The Common Assumptions effort has established a number of teams to address different areas required to develop consistency among the individual storage studies. Attaining consistency in modeling assumptions and analytical approach will allow the surface storage projects' performance, costs, and benefits to be compared and will inform decisions about project prioritization. The Common Assumptions process also makes more efficient use of limited technical resources.

Developing Project Alternatives

One of the next key steps in the surface storage planning process is developing project alternatives that meet the requirements of federal, State, and local participants. Alternatives development requires identifying and solving specific problems and needs. To date, USBR and DWR have developed general modeling scenarios for the five surface storage investigations. To develop project alternatives, additional detail will be needed to describe the specific goals of potential federal, State, and local participants. Project feasibility studies and environmental documents can be completed when potential participants are able to provide more specificity regarding their needs and interests.

The CALFED surface storage investigations are refining project alternatives and evaluating the level of potential participants' interests. The federal planning process is being used to determine if a federal interest exists for a specific project. In addition, USBR and DWR are working directly with potential participants by performing requested studies and are providing information to these participants as they perform their own evaluations to determine if the surface storage projects can contribute to meeting their specific water resource needs.

USBR and DWR have begun environmental documentation on three of the projects (NODOS, IDSP, and USJRBSI). These reports are being prepared concurrently with the federal feasibility planning process. However, until alternatives are developed, detailed impact analyses cannot be completed. Utilizing the planning process, identifying each surface storage project's broad public benefits and working directly with potential participants to assess their needs and interests in specific surface storage projects, the needs of all participants should be identified when the feasibility studies and the environmental documents are developed.

Recommendations to Help Promote Implementation of CALFED Surface Storage

1. CALFED signatories and stakeholders should continue to prioritize work efforts to complete the feasibility and environmental studies of the surface storage projects identified in the ROD.
    - As indicated in the funding discussion above, DWR is prioritizing future surface storage work efforts due to insufficient funding to complete environmental documentation and feasibility analyses for all five CALFED surface storage investigations. Prioritization criteria include reviewing conclusions and recommendations from ongoing State and federal planning studies; determining federal, State, and local interest, including willingness to pay; and assessing legal and logistical issues related to specific projects.
    - The investigations should continue to test all five potential projects against CALFED solution principles and implementation commitments as well as other local, State, and federal planning criteria for deciding to move to construction of any projects.
    - Engage more stakeholders and potential project participants in the process.

- Develop information on how the projects could be operated for a variety of purposes, costs, and impacts.
- Continue evaluation and presentation of operational scenarios that will allow potential participants to assess their interest in specific projects.
- Develop mechanisms to provide assurances that projects will be operated in a manner consistent with the objectives.

2. DWR, USBR, other CBDA agencies and local interests should cooperatively develop specific project alternatives for the CALFED surface storage projects for use in planning.
3. CBDA, DWR, and the USBR should continue their development of conceptual finance plans that will include descriptions of relevant State and federal financial policies and a determination of the potential for State and federal investment in benefits to the general public. The scenarios and finance plans will help facilitate potential investment decisions by local, regional, State and federal decision-makers.

Selected References

CALFED Programmatic EIS/EIR and ROD, CALFED, July and August 2000

North-of-the-Delta Offstream Storage Investigation Progress Report, DWR, July 2000

North-of-the-Delta Offstream Storage Scoping Report, DWR, October 2002

Initial Surface Water Storage Screening Report, CALFED, August 2000

Draft Project Concept Report, Contra Costa Water District, August 2002

In-Delta Storage Program Draft Summary Report and supplemental reports on operations, water quality, engineering, environmental, and engineering evaluations, DWR, May 2002

In-Delta Storage State Feasibility Study Draft Reports, DWR, January 2004

Flow Regime Requirements for Habitat Restoration along the Sacramento River between Colusa and Red Bluff, CALFED, Revised February 14, 2000

Upper San Joaquin River Basin Storage Investigation, In-Progress Review, Initial Surface Storage Options Screening, U.S. Bureau of Reclamation, November 2002

Upper San Joaquin River Basin Storage Investigation, Phase 1 Investigation Report, U.S. Bureau of Reclamation, October 2003

Shasta Lake Water Resources Investigation Mission Statement Milestone Report, U.S. Bureau of Reclamation, March 2003

California Bay-Delta Surface Storage Program Progress Report, DWR and U.S. Bureau of Reclamation, April 2004www.storage.water.ca.gov/docs/Briefing_Report.pdf

California Bay-Delta Surface Storage Program Progress Report, DWR and U.S. Bureau of Reclamation, April 2005
www.storage.water.ca.gov/public_docs.cfm

Project websites: Shasta Lake Water Resources Investigations: www.usbr.gov/mp/slwri
North-of-the-Delta Offstream Storage:
www.storage.water.ca.gov/northdelta/index.cfm
In-Delta Storage:
www.storage.water.ca.gov/indelta/index.cfm
Los Vaqueros Reservoir Enlargement:
www.lvstudies.com
Upper San Joaquin River Basin Storage Investigation:
www.usbr.gov/mp/sccao/storage

Volume 2

Chapter 18 Surface Storage – Regional/Local

Surface storage plays an important role in California where the pattern and timing of water use does not always match the natural runoff pattern. Contra Costa Water District pumps high quality water into its Los Vaqueros Reservoir and uses it to lower salt content of water it pumps from the Delta. (DWR photo)

Chapter 18 *Surface Storage – Regional/Local*

Surface storage is the use of reservoirs to collect water for later release and use. Surface storage has played an important role in California where the pattern and timing of water use does not always match the natural runoff pattern. Most California water agencies rely on surface storage as a part of their water systems. Similarly, surface storage is often necessary for, or can increase, benefits from other water management activities such as water transfers, conjunctive management and conveyance improvements. Some reservoirs contribute to water deliveries across several regions and some only contribute to water deliveries within the same watershed. Surface reservoirs can be formed by building dams across active streams or by building off-stream reservoirs where the majority of the water is diverted into storage from a nearby water source.

Surface storage capacity can also be developed by enlarging, reoperating (see the System Reoperation narrative) or modifying outlets on existing reservoirs. Smaller reservoirs typically store water in one season for use in another season, while larger reservoirs can do the same or store water for use over several years.

This strategy covers regional and local surface storage alternatives not currently under State and federal investigations as described in the CALFED Record of Decision. However, regional/local storage alternatives might include projects that are being investigated by CALFED but not ultimately implemented. They might also include storage alternatives that were eliminated at any juncture of the CALFED process since regional/local priorities and principles may be different than those used by CALFED. The potential CALFED surface storage projects are described in Chapter 17, Volume 2.

Surface Storage in California

California has nearly 200 surface storage reservoirs greater than 10,000 acre-feet with a combined storage capacity of more than 41 million acre-feet. In addition, many smaller reservoirs are used to provide for a wide range of water uses, stabilize water delivery to customers and provide a backup for emergency supply. Similar to many other parts of the world, most California reservoirs were developed over 30 years ago. As of the mid-1990s, there were about 1,242 dams being built worldwide – 55 in the United States[1]. In California, nearly 40 dams have been built over the past decade[2]. Examples of recently completed surface storage reservoirs completed by local/regional entities include: Olivenhain, Los Vaqueros, Diamond Valley and Seven Oaks reservoirs. The primary benefits of these new reservoirs are related to flood control (Seven Oaks), water quality, system flexibility, and system reliability against catastrophic events and droughts rather than for traditional water supply.

Over the past several decades, fisheries have received improved benefits from surface storage reservoirs through regulation and legislation. Specifically, many existing reservoirs have been managed to achieve ecosystem and other benefits beyond water supply. As water supplies dedicated to meeting both environmental and urban uses have grown, the state's surface water system has become increasingly inflexible. Water and ecosystem managers have less ability to adapt as use and regulatory requirements frequently control operations.

The relative need for local surface storage development may be greatest in the interior mountainous areas of the state such as the Cascades and the Sierra Nevada. Although much of the

[1] United States Society on Dams, November 2000

[2] Source: CA Division of Safety of Dams; includes DSOD jurisdictional dams only.

water used throughout the state originates in the mountains, these locations generally possess a much narrower array of available water management strategies to meet local needs. This is largely due to geographic, hydrogeologic or hydrologic limitations. Of these few strategies, some form of surface storage may hold the greatest potential for achieving local supply reliability objectives. Local surface storage development options include the reoperation of existing reservoirs, increasing the yield of existing reservoirs through expansion of their capacity, or construction of new reservoirs.

Potential Benefits of Surface Storage

Many of California's reservoirs were originally built for the primary purposes of hydropower, flood control, and consumptive water use. Although the allocation of benefits for proposed surface storage can affect the occurrence and magnitude of different types of benefits, they generally can include the following:

- Water quality management
- System operational flexibility
- Power generation
- Flood management
- Ecosystem management
- Sediment transport management
- Recreation
- Water supply augmentation
- Emergency water supply

The presence of new surface storage could allow ecosystem and water managers the flexibility to take actions and make real-time decisions that would not be possible without the storage. Water transfers between regions could be easier if water can be released from upstream storage at appropriate times and the receiving regions have reservoirs to store the transferred water. Surface storage can improve the effectiveness of conjunctive water management strategies by more effectively capturing runoff that can ultimately be stored in groundwater basins.

Storage projects can improve the movement of water at times to improve source water quality directly or facilitate blending of water from different sources to optimize system water quality. New surface storage can help provide water resources assets for the CALFED Environmental Water Account and Environmental Water Program, and for refuges. New surface storage can also help reduce the risk associated with potential future climate change by mitigating the effects of a relatively smaller seasonal snowpack storage capacity as well as increased or more sustained peak flood flows.

Potential Costs of Surface Storage

Cost estimates for potential surface storage alternatives are not specified in this narrative since they are only useful if created for a specific project with defined operation rules and allocation of benefits and costs. The costs of multipurpose storage projects will be shared by many beneficiaries. The magnitude of the benefits and corresponding costs for such things as water supply, water quality and flood management can be expected to vary significantly from project to project.

Major Issues Facing Surface Storage

Identifying Beneficiaries

There are concerns related to how the beneficiaries will be determined, who will actually pay, and who will control the storage operation. The challenge is to develop financial and operations agreements for the multiple beneficiaries and uses.

Funding

Construction usually requires a lot of money in a short time – perhaps $1 billion or more over five years for larger projects. Included in the long-term capital outlay are planning costs such as administrative, engineering, legal, financing, permitting and mitigation, which can also require significant investments. Some new storage options such as raising existing reservoirs, reoperating them or the construction of small local reservoirs may require significantly less capital, but may require local funding through revenue or general obligation bonds. Even these less costly projects could face financial challenges.

Impacts

New storage can affect environmental and human conditions, create economic impacts for the surrounding community, and flow impacts both up and downstream of diversions. New reservoirs may result in the loss of property tax revenue to local governments in the area they are located, or by increasing local property values by firming up a water supply. Regulatory and permitting requirements require surface storage investigations to consider potential impacts to stream flow regimes, potential adverse effects on designated wild and scenic rivers, potential water quality issues, potential changes in stream geomorphology, loss of fish and wildlife habitat, and risk of failure during seismic and operational events. Existing environmental laws require that these types of effects be mitigated. Mitigation of environmental effects is normally accomplished through implementation strategies that avoid, minimize, rectify, reduce over time, or compensate for negative impacts. New surface storage projects may need to address impacts under the application of various laws, regulatory processes and statutes such as Public Trust Doctrine, State dam safety standards, Area of Origin statutes, California Environmental Quality Act, National Environmental Protection Act, the Clean Water Act and the Endangered Species Acts.

Suitable Sites

Most of the best reservoir sites have already been used and the new standards of environmental regulations are significant constraints to development of surface storage in the mountains. The range of surface storage development options for smaller local agencies is more limited than for the State and federal governments. Local agencies have limited ability to use State or federal funds, nor do they have the ability to work as closely with their corresponding resource regulatory agencies such as the State and federal agencies do as part of CALFED. Additionally, there are physical limitations on storage options in some parts of the state. In some areas, offstream storage is not feasible. These circumstances severely constrain the ability of local governments and agencies to finance and implement the projects necessary to sustain the local economy and serve increasing populations.

Science

Biologists and water managers continue to struggle to identify and understand the relationships between hydrodynamics, flow timing, water temperature, geomorphology, water quality, environmental responses, and other conveyance related considerations. Increased understanding of these considerations will enable resource planners and managers to better determine the causes of observed impacts and hence, more effectively restore, preserve and manage at-risk resources, such as modified operations and environmental mitigation.

Recommendations to Better Manage and Increase Surface Storage Benefits

1. Local agencies seeking to implement storage projects should develop a comprehensive methodology for analyzing all benefits and full costs of projects. DWR should provide technical expertise and assistance to the local agencies if asked.
2. Reservoir operators and stakeholders should continue to adaptively manage operations of existing facilities in response to increased understanding of system complexities and demands as well as changes in natural and human considerations such as social values, hydrology, and climate change.
3. DWR and other local, State and federal resource management agencies should continue studies, research and dialogue focused on a common set of tools that would help determine the full range of benefits and impacts as well as the costs and complexities of surface storage projects.
4. Water resources scientists, engineers and planners, including DWR should recognize the potential long development time for new surface storage in securing funding needed for continuity of planning, environmental studies, permitting, design, construction, and operation and maintenance.

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Chapter 19 System Reoperation

System reoperation may improve the efficiency of existing uses, or it may increase the emphasis of one use over another. The temperature control device at Shasta Dam allows operators to operate the dam for salmon protection and recovery, as well as hydroelectric power production. (DWR photo)

Chapter 19 *System Reoperation*

System reoperation means changing existing operation and management procedures for such water facilities as dams and canals to meet multiple beneficial uses (see Box 19-1). System reoperation may improve the efficiency of existing uses, or it may increase the emphasis of one use over another. In some cases, physical modifications to the facilities may be needed to expand the reoperation capability. Population growth, with its commensurate demand for more water, better understanding of the environmental impacts of water development, and changing laws and values, have created incentives to evaluate how existing facilities can be reoperated to provide the best use of the facilities.

Extent of System Reoperation

System reoperation is not a new tool for water managers. A 1976-1977 drought prompted many water agencies to move away from the firm-yield approach to operating water projects to a risk-based approach when making system delivery decisions. The firm-yield approach seeks to deliver the same amount every year regardless of water supply conditions while the risk-based approach balances increasing deliveries in a given year with the risk of not meeting full deliveries in a subsequent dry year. The risk-based approach has increased average deliveries of the State Water Project. Several large-scale regulatory and water planning and management efforts started over the past decade have prompted project operators to explore system reoperation. These efforts include implementation of the Central Valley Project Improvement Act (CVPIA), SWRCB Bay-Delta Decision 1641, The CALFED Bay-Delta Program, and hydroelectric facility relicensing. Concerns about the potential effect of global climate change have also influenced reoperation planning.

Box 19-1 Examples of System Reoperation

- Changes in timing or volume of reservoir water storage and releases to accommodate changing priorities of the project, such as improving or managing instream conditions, recreation opportunities, flood management, local water supplies, or water quality.
- Using temperature control devices in reservoirs to permit water to be released from variable depths in order to manage the water temperature and water quality downstream for endangered species protection while maintaining hydroelectric power generation.
- Increasing the water storage and flood retention capacity of reservoirs by conveying reservoir water to groundwater banks before the refill season.
- Coordinating and interconnecting water storage, water conveyance, and water delivery systems within a watershed or geographic area to improve benefits to the local watershed area, the regional watershed area, and the state.
- Balancing water supply and delivery forecasts with the economic and environmental risks that water users and regulatory agencies may be willing to accept if full deliveries are not met. The ability to customize risk tolerances to users may allow overall improvements in system efficiency.

The CVPIA, signed into law October 30, 1992, mandated changes in management of the Central Valley Project, particularly for the protection, restoration, and enhancement of fish and wildlife. This has led to changes in water supply contracts, reallocation of water for environmental benefits, increased use of voluntary water transfers, and implementation of water use efficiency measures. One example of reoperation that was prompted by CVPIA was the installation of the Temperature Control Device (TCD) at Shasta Dam at a cost of $80 million. The TCD is a shutter type mechanism designed to draw water from the different levels of Shasta Lake and release it through powerhouse turbines, providing cold water for endangered winter run Chinook salmon spawning downstream in the Sacramento River, while maintaining hydroelectric power generation. Water is drawn from different levels of the lake at different times of the year to match the downstream requirements and to manage the cold water reserves behind the reservoir.

The State Water Resources Control Board adopted Decision 1641 (D-1641) on December 29, 1999. The decision implements flow and water quality objectives for the Bay-Delta Estuary set forth in the 1995 Bay-Delta Plan, adopted May 22, 1995. D-1641 recognizes that many of the objectives in the 1995 Bay-Delta Plan are best implemented by making changes in the flow of water or in the operation of export facilities. Accordingly, D-1641 includes aspects of system reoperation by approving changes to points of diversion of the Central Valley Project and the State Water Project in the southern Delta, and approving changes in places of use and purposes of use of water developed and distributed by the Central Valley Project.

The purpose of CALFED Bay-Delta Program is to develop and implement a long-term comprehensive plan that will restore ecological health and improve water management for beneficial uses of the Bay-Delta system. The program was formalized with the approval of the Record of Decision on August 28, 2000, by the state and federal agencies with management and regulatory responsibility in the Bay-Delta Estuary. The Framework Agreement pledged that the state and federal agencies would work together in three areas of Bay-Delta management: 1) Water quality standards formulation; 2) Coordination of State Water Project and Central Valley Project operations with regulatory requirements; and 3) Long-term solutions to problems in the Bay-Delta Estuary. All three components include system reoperation combined with other water management strategies to make improvements. The Environmental Water Account (EWA) is an element of the CALFED Bay-Delta Program's overall management strategy for the Bay-Delta ecosystem. EWA's purpose is to provide greater protection to the fish of the Bay-Delta Estuary than current regulatory requirements through environmentally beneficial changes in the operations of the CVP and SWP at no uncompensated water cost to the projects' users.

About a third of hydroelectric plants in California licensed by the Federal Energy Regulatory Commission (FERC) must undergo review and relicensing by 2015. Because FERC issues licenses for a period of 30-50 years, relicensing provides an opportunity to assess and change license conditions for many facilities over a relatively short period. Many of these facilities were designed, constructed, and licensed before environmental laws like CEQA and NEPA were in effect and before the California Supreme Court clarified, in National Audubon Society v. Superior Court of Alpine County (1983), the State's public trust responsibilities to protect the people's common heritage of streams, lakes, marshlands and tidelands. The result is that planning for many projects did not fully evaluate potential impacts to rivers in the timing and volume of instream flows, sediment transport, water temperature, and fish passage. Operational changes are being made during relicensing to ensure that the projects are in compliance with modern environmental laws, public trust, public policy and the public interest.

Global climate change has also prompted discussion of system reoperation. The specific effects of global climate change on water resource management in California are uncertain. Climate change could result in altered snowpack accumulation and melting, runoff patterns, water supply, sea level, floods and droughts, water demands, water temperature, plant and animal life including livestock, hydroelectric power, wild fires, recreation, water quality, soil moisture, groundwater, and ecosystems. California water managers continue to evaluate climate change and study ways of incorporating flexibility into the system to respond to climate change.

Potential Benefits of System Reoperation

Statewide benefits of system reoperation are difficult to estimate since the potential benefits are generally project-specific. The State Water Project and Central Valley Project have integrated operations since the 1970s with annual agreements that were eventually finalized in 1986 with the signing of the Coordinated Operating Agreement. This agreement has led to significant improvement in how the two projects coordinate to provide water to meet consumptive and environmental uses. The CALFED Bay-Delta Program is evaluating system reoperation, including recirculation of Delta exports, to manage salinity in the San Joaquin River. Part of this reoperation would be to use excess capacity from the Tracy pumping plant, the Delta Mendota Canal, the SWP Banks pumping plant, or the California Aqueduct to convey water for subsequent release into the San Joaquin River to reduce salinity concentrations.

System reoperation integrates multiple resource management strategies such as surface storage, conveyance facilities, conjunctive management, water-dependent recreation and ecosystem restoration, which can:

- Reduce conflicts between competing beneficial uses and allow for improvements to the beneficial uses including environmental, recreational, water quality, and water supply objectives.
- Provide additional flexibility to respond to extreme hydrologic events like flood and drought or catastrophic events like earthquakes.

Box 19-2 Case Example of System Reoperation El Dorado Irrigation District's Project 184

El Dorado Irrigation District's (EID's) Project 184 highlights the potential benefits, costs, and issues surrounding system reoperation as part of FERC relicensing. Project 184 is a 21 megawatt hydroelectric and water supply project located on the South Fork of the American River and its tributaries, and on Echo Creek, a tributary to the Upper Truckee River, in the counties of El Dorado, Alpine, and Amador, California.

In February 2000, EID filed an application to renew its license with FERC. The relicensing of Project 184 involved a collaborative process to provide significantly enhanced environmental protection, improving recreational opportunities and for assuring the long-term reliability and economic viability of local water supply. In April 2003, the effort produced a settlement agreement, which has been filed with FERC as recommendations for establishing conditions for the new license:

- Lake level criteria for improved recreation opportunities
- Improved aquatic habitat via new stream flow criteria in more reaches of stream
- Pulse flows in regulated reaches to mimic natural hydrologic condition peak flows
- Recreation facility improvements including a new boat ramp, campground access improvements, whitewater boating access improvements
- Fish screens at diversions from Alder and Carpenter Creeks
- Public information system of real-time lake and flow data via internet and phone
- Stream restoration in previously scoured reaches
- Sensitive species, fish and water quality monitoring
- Various environmental protection plans for operation, maintenance, and future capital projects
- Ecological resources adaptive management program

Although implementation of the new license conditions may result in a slight reduction in revenues depending on future power values, revenues from power generation can be augmented with revenues from consumptive water deliveries in order to fund project costs. EID benefits by maintaining the power generation features of the project because revenues from hydroelectric power generation offset the majority of project costs which are largely driven by the cost of water conveyance, an integral system component that would exist with or without power generation capability.

Even with the collaborative process and settlement agreement, the proposed reoperation is not entirely free of controversy. At least one interested party representing some of the recreation and business interests around Caples and Silver lakes has not signed on to the settlement agreement because of concerns about potential economic and quality of life impacts from the revised operation. Although lake level and streamflow conditions under the system reoperation would generally be enhanced for recreation interests compared to historic project operations, disagreement continues over what lake levels should be maintained during the summer and fall recreation season, if the lakes refill from year to year, and how low lake levels will be allowed to drop during dry years.

Potential Costs of System Reoperation

The potential direct costs for implementing system reoperation are project-specific and are difficult to extrapolate to a statewide estimate. Up-front costs may include performing the feasibility studies, completing California Environmental Quality Act and National Environmental Protection Act analysis, and undergoing water rights permitting to implement a proposed change in operation. These studies alone can cost millions of dollars and take several years to complete. Long-term costs may include capital costs for the construction, modification, or removal of facilities, loss of revenue from reduction in sale of hydropower or water supplies, and increased operations and maintenance costs.

Major Issues Facing System Reoperation

Reduced Hydropower Generation

System reoperation has the potential of shifting some water use from hydropower generation to other uses. Preliminary analyses by the California Energy Commission indicate that project-specific and cumulative reductions in hydropower generation associated with FERC relicensing are not significant on a systemwide basis in California. However, many facilities must still undergo relicensing and the effects of these on energy generation must be evaluated. Improved generating equipment and technology can offset some of this energy reduction. There may be a need to provide for alternative sources of energy to make up any reduction in hydropower generation. If reoperation occurs on a large scale, switching to fossil fuels to offset these reductions in hydropower generation could increase air pollution, and reliance on imported energy sources.

Gaps in Scientific Knowledge and Data

There are several significant knowledge gaps that should be addressed to improve the likelihood of successful system reoperation. There is a need for greater understanding of the relationships between flow patterns, the response of aquatic ecosystems, and how these relate to protecting public trust resources. While this area of applied environmental science is developing quickly, there is a need to improve the understanding of the effects of pulsed and ramped flows upon endangered species, other aquatic species, habitats, and river morphology. Lack of baseline data and good bio-hydrologic models for some ecological components are limiting factors. Biological opinions issued by the U.S. Fish and Wildlife Service and the National Marine Fisheries Service have provided some guidance on specific changes in operation that would benefit specific endangered species. There is also a gap in the understanding of the specific effects associated with global climate change on local water systems. Changes in the timing and distribution of precipitation and runoff within the state can create greater uncertainty, potentially requiring changes to the management of the water system. There is a need for improved runoff prediction and other scientific information to support water management decisions.

Competing Beneficial Uses

In some cases, the analysis of reservoir reoperation can be as complex and controversial as that associated with new facility construction. Because many dams and conveyance have been operating the same way for decades, it is important to consider the interests of today's beneficiaries before introducing dramatic changes. For example, many reservoirs have existing uses including recreation, summer homes, wetland habitat and fisheries. In addition, reoperation could have unintended impacts to existing ecological processes; those impacts must be evaluated. There is concern about direct and indirect impacts on other users including downstream water rights, the environment, recreational uses, and energy production.

Conveyance Constraints

The capacity of reservoir outlets, storage, pumping, and conveyance might limit the ability to perform system reoperation through such things as water transfers, conjunctive management or revised flood operations.

Area of Origin Water Rights

Historically, area of origin water rights have not been widely exercised, but they are increasingly of interest as rural counties develop. It may be possible for these areas to develop agreements with project operators to meet some of these projected demands through reoperation of existing facilities rather than through construction of new facilities. However, new facilities may provide more flexibility to the overall management of the system. Agreements with existing facility operators to change operations would need to consider existing uses.

Integrating Water Resource Management

There are many tiers of management of developed water resources. These include facilities that are operated for local, regional, or statewide beneficial uses. Implementing system reoperation to obtain wider system benefits can require regulatory actions by several local, State, and federal agencies. For example, hydropower relicensing may include actions by the California Department of Fish and Game, the State Water Resources Control Board, the U. S. Forest Service, U.S. Fish and Wildlife Service, the National Marine Fisheries Service, and the Federal Energy Regulatory Commission. Efforts to increase coordination among both the physical operation of the facilities and the regulatory agencies can result in greater opportunities to achieve broader benefits within each watershed.

Implementation Costs

Significant up-front and on-going costs can be involved with system reoperation. Costs might include developing monitoring systems, hydrologic models, decision support systems, and collecting data to evaluate benefits and impacts of proposed changes. Other costs are associated with conducting feasibility studies, completing CEQA/NEPA analysis, and constructing new or modifying or removing existing facilities. Agencies might have difficulty raising the needed funds because of existing contracts or regulations that prohibit them from increasing water or energy rates.

Water Quality

Water quality can restrict the ability to modify existing operations for other benefits. For example, the need to maintain cold-water temperature reserves in reservoirs for downstream fisheries may prohibit reducing reservoir storage levels during the certain seasons for water supply. Reoperation using surface water to actively recharge groundwater banks may be limited by existing groundwater or recharge water quality. Water quality is often more critical for reoperation for local benefits than for regional and statewide benefits.

Recommendations to Further System Reoperation

1. The following recommendations (bulleted items) are derived from the California Energy Commission's Public Interest Energy Research Program to gain a better understanding of the effects of flow release patterns on California stream habitats and biotic communities:
   - Review the availability and quality of scientific data related to the ecological impacts associated with the operation of water management facilities.
   - Determine the adequacy of current and new sampling and analytical methods to detect and predict potential effects.
   - Develop a recommended protocol for assessing possible ecological impacts.
   - Develop and disseminate research to enhance scientific understanding and assessment of effects.
2. The State should provide financial and technical assistance for feasibility studies and evaluations that could lead to enhanced management of water resources through system reoperation. Give priority for funding and technical assistance to system reoperation projects with multiple benefits.
3. The State should continue to study the potential impacts of global climate change on water management in California and develop potential strategies to respond to these impacts.
4. Project operators should improve runoff forecasting and decision support systems for reservoir reoperation to manage water resources among competing demands.
5. The State should support research that improves our understanding of flow alteration effects on aquatic ecosystems and support development of management tools to address these effects.

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Chapter 20 Urban Land Use Management

The way in which we use land—the type of use and the level of intensity—has a direct relationship to water supply and quality. (DWR photo)

Chapter 20 *Urban Land Use Management*

Effective urban land use management consists of planning for the housing and economic development needs of a growing population while providing for the efficient use of water and other resources. The way in which we use land — the type of use and the level of intensity — has a direct relationship to water supply and quality.

Urban Land Use Patterns in California

Existing urban development patterns reflect a strong consumer demand for single family homes in suburban locations. Local government and private sector decisions on the placement of offices, industrial sites and retail centers are driven by a combination of workforce availability and state tax policy. Because only 5 percent of California's land area is in urban development, and 50 percent of the state is in public ownership, the result of current development practices is the consumption of farm land, open space, habitat, and other natural resources. Although it comprises a relatively small portion of most watersheds, impervious surfaces such as roads and parking lots result in more rapid and larger amounts of surface runoff. This change in runoff can alter stream flow and watershed hydrology, reduce groundwater recharge, increase stream sedimentation, and increase the need for infrastructure to control storm runoff.

Higher density development and more efficient land use can be encouraged through changes in consumer preferences and public policies to promote more compact development (see Box 20-1 for recent State policies and guidelines). In some of the most densely populated regions of the state, including the San Francisco Bay Area and Los Angeles, headway is being made to grow more compactly, provide jobs closer to housing, and provide transit to connect people with community resources.

Local agency formation commissions (LAFCOs) are regional planning agencies that were established to encourage logical and efficient development patterns. With the recent changes to Government Code § 56000 et. seq., LAFCOs are now required to perform municipal service reviews on a regular basis. This will allow a comprehensive evaluation of how all services, including water, are delivered to developing areas of the state.

Potential Benefits of More Compact Development

There are water-related benefits that accrue from more compact development. It can reduce landscaped areas and therefore reduce landscape water use. Although higher density development may actually increase impervious surfaces and increase traffic congestion in urban areas, it may reduce the total development footprint in the state and reduce urbanization impacts to habitat, watershed functions, and groundwater recharge areas.

Compact, mixed-use development can reduce water demand, even with moderate increases in density. As a rule of thumb, landscaping irrigation accounts for almost half of residential water use. An increase in residential density from four units per acre to five reduces the landscaping area by 20 percent, which should cut water usage by roughly 10 percent compared to the lower density development. A smaller urban footprint reduces impervious surfaces. This generates less surface runoff, and minimizes intrusion into watersheds and groundwater recharge areas which receive the runoff.

The Legislature and Governor Arnold Schwarzenegger via Assembly Bill 2717 (Laird, 2004) asked the California Urban Water Conservation Council to convene a Landscape Task Force with representatives from water suppliers, environmental groups, government agencies, and the landscape and building industries to evaluate landscape water use efficiency and make recommendations for improvements. The AB 2717 Landscape Task Force is currently evaluating in great detail the potential for water savings for both new and existing development. The recommendations of the Task Force may lead to significant improvements in landscape irrigation through new Model Landscape Ordinance policies, new technologies, changes in rate structures, and new legislation. The Task Force will finish its work and submit a final report to the California Legislature and Governor by December 31, 2005 (See the Urban Water Use Efficiency strategy, Chapter 22, Volume 2 for the draft recommendations by the Landscape Task Force).

Potential Costs

No statewide cost estimates are available for implementing this strategy. The potential state, local and private costs for promoting higher density and more compact development need to be balanced with the need for more housing, economic development and consumer preferences.

There could be significant new costs associated with changing the way local, regional, and State agencies plan urban areas. Among these are costs for increased communication, coordination and information sharing between land use agencies, water suppliers, and agencies which regulate water quality.

However, by implementing this strategy, there will likely be lower long-term costs associated with reduced urban runoff, less infrastructure expansion for water supply, and lower mitigation costs for displaced farm land and/or wildlife habitat.

Major Issues

Disincentives for Change

Local governments make most of the land use decisions in California. There are many reasons why local governments do not use more resource efficient development patterns including: consumer preferences and demands for single family homes with yards, community resistance to infill or higher density development, local zoning ordinances which have not been updated for many years, the added cost to conduct regional planning efforts, the cost and liability associated with pursuing infill projects, and environmental mitigation strategies that encourage lower density development. In addition, landscape, soils, environmental hazards and infrastructure limitations are additional factors that guide local governments in the development of land use policy decisions. Changing land use planning practices and development standards statewide would be a significant and expensive public policy undertaking with as yet unknown water use savings compared to more direct methods of water conservation.

Coordination

Recent changes to the Government Code and the Water Code requires local governments to determine whether there will be enough water to supply a proposed development project before it can be approved. This will require land use agencies and water agencies to improve their communication and

Box 20-1 Recent State Policy and Guidelines

Statute AB 857 (Stats. 2002; ch. 1016) establishes three planning priorities and requires that all State strategic plans and capital improvement plans—including the next update of the Governor's Environmental Goals and Policy Report and the California Water Plan—be consistent with them.

- Promote infill development and equity,
- Protect environmental and agricultural resources, and
- Encourage efficient development patterns.

The State of California General Plan Guidelines, updated in 2003 (OPR), recommends that local governments consider preparing an optional Water Element in their general plans.

Three bills, SB 221, SB 610 and AB 901, were enacted by the Legislature to improve the coordination between water supply and land use planning processes at the local level and became effective January 1, 2002. The new laws are intended to improve the assessment of water supplies during the local planning process before approval of land use projects that depend on water. They require verification of sufficient water supplies as a condition for approving developments, compel urban water suppliers to provide more information on groundwater reliability if used as a supply, and require average and drought year conditions be addressed.

coordination on project-level development decisions that have been made independently in the past. Many of the water supply coordination issues for new development are now addressed in the state's Water Code through existing requirements for the preparation and approval of Urban Water Management Plans every five years and the implementation of SB 610 (Costa) and SB 221 (Kuehl) enacted in 2001. Increased coordination will also be necessary among all levels of government to coordinate inter-agency planning, to develop databases, and to interpret and share data and information.

Recommendations

State

1. Provide incentives to developers and local governments to plan and build using more resource efficient development patterns. This can be done through CEQA exemptions for infill development, reductions in brownfield liability for innocent land purchasers, prioritizing planning grants and other incentives to increase consumer interest in urban living and to encourage infill and compact development forms.
2. Encourage local governments to review the Urban Water Management Plans adopted by water agencies within their jurisdiction; and to work with these water agencies to show compliance with Water Code sections that require local governments to consider water supply availability when making land use decisions for significant (500 homes or more) new development projects, and to prepare the water resource section of their general plans as described in the State's General Plan Guidelines Update (OPR, 2003).
3. Provide technical assistance to local governments on how to incorporate resource efficient development into their local general plan, related zoning ordinances, and specific plans; and how to prepare required water supply assessments before approving major new development projects.
4. Develop and publicize accurate and relevant data on water supply and water quality to help local agencies plan.
5. Encourage more research on the impacts of resource efficient development patterns and best practices.

Local Government

6. Recognize regional needs and resources when developing local general plans and designing and building neighborhoods and communities. Improve communication, coordination and information-sharing with other local agencies, regional planning agencies, and local water agencies and watershed managers.
7. Promote the rehabilitation of aging or inadequate infrastructure to help infill development.
8. Evaluate the potential environmental impacts of new development on prime agricultural land, open space, floodplains, recharge areas and wetlands and consider the water supply impacts when developing appropriate mitigation measures.
9. Update landscape irrigation ordinances to promote consumer choices for more water-efficient landscaping in existing and new developments.
10. Look for opportunities to reduce impervious surfaces, especially near waterways.

Regional Government

11. LAFCOs should consider water supply issues in the context of their charge to encourage logical and efficient development patterns that minimize impacts on agricultural land and maximize meeting housing needs and affordability.

Water Suppliers

12. Develop and make available water resource information, such as water supply and water quality in Urban Water Management Plans, to local governments that can be used in local and regional land use decisions, including general plan formulation and municipal service reviews.
13. Collaborate with local land use agencies to assess water supply availability for new development.

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Chapter 21 Urban Runoff Management

Traditionally, urban runoff management was viewed as a response to flood control concerns resulting from the effects of urbanization, but concerns about water quality impacts have led water agencies to look at watershed approaches to control runoff and provide other benefits. The Santa Monica Urban Runoff Recycling Facility helps protect coastal waters by treating water diverted from the city's storm drains. (DWR photo)

Chapter 21 *Urban Runoff Management*

Urban runoff management is a broad series of activities to manage both stormwater and dry-weather runoff. Dry weather runoff occurs when, for example, excess landscape irrigation water flows to the storm drain. Urban runoff management is linked to several other resource strategies including pollution prevention, land use management, watershed management, water use efficiency, recycled water, protecting recharge areas, and conjunctive management. Traditionally, urban runoff management was viewed as a response to flood control concerns resulting from the effects of urbanization. Concerns about the water quality impacts of urban runoff have led water agencies to look at watershed approaches to control runoff and provide other benefits.

Urban Runoff Management in California

The traditional approach to runoff management views urban runoff as a flood management problem where water needs to be conveyed as quickly as possible from urban areas to waterways to get rid of it. Urbanization alters flow pathways, water storage, pollutant levels, rates of evaporation, groundwater recharge and surface runoff, the timing and extent of flooding, the sediment yield of rivers, and the suitability and viability of aquatic habitats. The traditional approach has been successful at preventing flood damage, but has several disadvantages. In order to convey water quickly, natural waterways are often straightened and lined with concrete, resulting in a loss of habitat, a reduction in groundwater recharge from streams, and impacts to natural stream physical and biological processes. This collects pollutants and increases runoff volume and speeds its flow, resulting in pollution, stream bank erosion, and potentially flooding problems downstream. Because of the emphasis on removing the water quickly, the opportunity to use water for multiple benefits is reduced.

The watershed approach for urban runoff management tries to emulate and preserve the natural hydrologic cycle that is altered by urbanization. The watershed approach consists of a series of best management practices (BMPs) designed to reduce the pollutant load, volume, and flow rate of urban runoff reaching waterways. These BMPs may include requiring new facilities to capture, treat, and recharge groundwater with urban runoff, conducting public education campaigns for the

Box 21-1 Objectives of Urban Runoff Management

- Protection and restoration of surface waters by the minimization of pollutant loadings and negative impacts resulting from urbanization
- Protection of environmental quality and social well-being
- Protection of natural resources, e.g., wetlands and other important aquatic and terrestrial ecosystems
- Minimization of soil erosion and sedimentation problems
- Maintenance of the predevelopment hydrologic conditions
- Protection and augmentation of groundwater supplies
- Control and management of runoff to reduce or prevent flooding
- Management of aquatic and riparian resources for active and passive pollution control

proper use and disposal of household chemicals, and providing technical assistance and storm water pollution prevention training. Some areas advocate collecting rainfall from roofs into cisterns for later use. Methods for recharging groundwater with urban runoff include draining runoff from parking lots, driveways, and walkways into landscape areas with permeable soils, using drywells, and using permeable surfaces. These BMPs may include source control and pretreatment before infiltration. Infiltration enables the soil to naturally filter many of the pollutants found in runoff and reduces the volume and pollutant load of the remaining water when it reaches the outfall. The watershed approach will not prevent all urban runoff from entering waterways, so elements of the traditional conveyance and storage strategy will still be needed.

Urban runoff management has become more important and controversial over the last decade as municipal governments have been held increasingly responsible for nonpoint source pollutants washed into waterways from developed areas within their jurisdictions. Nonpoint source pollution, unlike pollution from industrial and sewage treatment plants, comes from many diffuse sources. Nonpoint source pollution is caused by rainfall or snowmelt moving over and through the ground. As the runoff moves, it picks up and carries away natural and human-made pollutants, finally depositing them into lakes, rivers, wetlands, coastal waters, and potentially into groundwater. Nonpoint source pollution also occurs from non-storm event activities, such as movement by wind, flows from landscape irrigation, improper disposal of trash or yard waste, and leaky septic systems.

The 1987 amendments to the federal Clean Water Act directed the U.S. Environmental Protection Agency (USEPA) to establish a permitting system under the National Pollutant Discharge Elimination System (NPDES) to regulate nonpoint source pollution from certain urban areas in order to protect water quality. In California, the authority to regulate urban and stormwater runoff under the NPDES system has been delegated by USEPA to the State Water Resources Control Board (SWRCB) and the nine Regional Water Quality Control Boards (RWQCBs). The state of California is required under Clean Water Act (CWA) section 303(d) and federal regulations (40 CFR 130) to prepare a list of and set priorities for waterways requiring Total Maximum Daily Loads (TMDLs) because they do not meet water quality standards. The section 303(d) list was last revised in 2002. Federal regulations require the section 303(d) list to be updated every two years. TMDLs represent the total pollutant load a waterway can assimilate before the waterway's beneficial uses are impacted. Nonpoint source runoff is frequently a significant source of pollutants in a waterway's total pollutant loading.

Because municipal governments are responsible for controlling urban runoff from streets and other public facilities within their jurisdictions, they are required to obtain an NPDES permit and implement specific measures to reduce the amount of pollutants in urban runoff. Permits for discharge to listed waterways having a TMDL must be consistent with the load assignments in a TMDL. Under California law TMDLs include implementation plans for meeting water quality standards. The implementation plans allow for time to implement control strategies to meet water quality standards. Under the initial NPDES permits issued in the 1990s municipalities were required to establish land use and development guidelines for both new and existing development to reduce the discharge of pollutants into waterways. These guidelines are usually a series of BMPs as described above. It has become clear with continued beach closures and other pollution problems associated with urban runoff that more advanced measures will be required in some areas to comply with water quality regulations.

Box 21-2 Examples of Nonpoint Source Pollution

- Herbicides and insecticides from residential landscaped areas, golf courses, city parks, etc.
- Oil, grease, and heavy metals illegally/improperly disposed of or accumulated on parking lots, streets and highways from automobiles, trucks, and busses
- Sediment from improperly managed construction activities
- Litter and green wastes
- Bacteria and nutrients from excess fertilizers, improperly maintained septic systems, and wastes from pets and wildlife

Potential Benefits of Urban Runoff Management

The primary benefits from urban runoff management are to reduce nonpoint source water pollution and improve flood protection. Additional benefits may be to increase water supply through groundwater recharge in areas with suitable soil and geological conditions, and improve wildlife habitat, parks and open space. Groundwater recharge and stormwater retention sites can be designed to provide additional benefits to wildlife habitat, parks, and open space. Underground infiltration facilities can temporarily store runoff and release it gradually to the aquifer while allowing the unimpaired use of the surfaces above them. For instance, a school campus can solve its flooding problem and develop a new sports field at the same time. These may provide secondary benefits to the local economy by creating more desirable communities in which to live. By keeping runoff onsite, storm drain systems can be downsized, reducing installation and maintenance costs of such systems. A watershed planning approach to manage urban runoff allows communities to pool economic resources and obtain broader benefits to water supply, flood control, water quality, open space, and the environment.

Statewide information on the benefits of increased management of urban runoff is not available, although examples from local efforts exist. The Fresno-Clovis metropolitan area has built an extensive network of storm water retention basins that not only recharges more than 70 percent of the annual storm water runoff (17,000 acre-feet) and removes most conventional storm water pollutants, but also recharges excess Sierra snow melt during the late spring and summer (27,000 acre-feet). Los Angeles County recharges an average 210,000 acre-feet storm runoff a year, which reduces the need for expensive imported water. Agencies in the Santa Ana Watershed recharge about 78,000 acre-feet of local storm runoff a year. The Los Angeles and San Gabriel Watershed Council has estimated that if 80 percent of the rainfall that falls on just a quarter of the urban area within the watershed (15 percent of the total watershed) was captured and reused, total runoff would be reduced by about 30 percent. That translates into a new supply of 132,000 acre-feet of water per year or enough to supply 800,000 people for a year.

Santa Monica is an example of a municipality that is taking a watershed approach to managing urban runoff. Santa Monica's primary goal is to treat and reuse all urban runoff. This turns a perceived waste product into a local water resource. Not only is water quality achieved, but a new water resource is harvested. This decreases the dependence on imported water, leaving this water supply in distant watersheds for uses there, especially in the case of Southern California where most of its water comes from Northern California rivers, Eastern Sierra snow melt and Colorado River. If necessary, because of high runoff, the city's secondary goal is to release only treated runoff into waterways. Both goals improve water quality of the Santa Monica Bay. The city's goals promote low-impact development and smart growth, two similar approaches to land use, in which urbanization works with nature and the hydrologic cycle.

Box 21-3 Five Year Implementation Plan for Nonpoint Source Pollution Program

The SWRCB and the California Coastal Commission in coordination with 26 other State agencies are finalizing the Five Year Implementation Plan for the Nonpoint Source Pollution Program, which includes management of urban runoff. The Implementation Plan recommends the following State actions:

- Promote coordination of interagency programs that protect water quality from urban runoff pollution.
- Reduce the potential for contamination of surface and groundwater that results from uncontrolled or poorly-controlled urban runoff practices.
- Develop tools to assess the effectiveness of urban water pollution programs.
- Increase the availability of regulatory and guidance documents and/or instructional workshops to demonstrate effective urban runoff pollution control programs and policies.
- Reduce the number of uncontrolled urban NPS pollution sources by increasing the number of municipalities, industries and construction sites that utilize NPS management measures and fit under the permitted State Storm Water Program.
- Develop and implement watershed-based plans, including TMDLs and Storm Water Pollution Prevention Plans (SWPPPs), in order to identify and address impacts from urban land use.

Potential Costs of Urban Runoff Management

Information is not available on statewide costs to implement urban runoff management activities. However, the State Water Resources Control Board has recently contracted with the Office of Water Programs, California State University, Sacramento, to survey six communities to estimate the costs of complying with their NPDES storm water permits. While this may address the cost for a municipality to comply with an NPDES permit, it may not be the most applicable for looking at watershed programs seeking multiple benefits.

An example from the city of Santa Monica illustrates the costs of managing urban runoff. The city has a stormwater utility fee that generates about $1.2 million annually, and has been in place since 1995. These funds are used for various programs to reduce or treat runoff. These funds go to the Urban Runoff Management Coordinator, the maintenance of the storm drain system, and help support other city staff that support runoff work. Additional funds are spent by other divisions to support runoff management, such as street sweeping, some trash collection, sidewalk cleaning, and purchase and maintenance of equipment. The city has also received five grants totaling more than $3.5 million for the installation of structural BMP systems, all of which will require long-term maintenance and monitoring by the city. The culmination of the city's program is the $12 million Santa Monica Urban Runoff Recycling Facility (SMURRF), a joint project of the cities of Santa Monica and Los Angeles. The SMURFF project is a state-of-the-art facility that treats dry weather runoff water before it reaches Santa Monica Bay. Up to 500,000 gallons per day of urban runoff generated in parts of the cities of Santa Monica and Los Angeles can be treated by conventional and advanced treatment systems at the SMURRF.

Major Issues

Lack of Integration with Other Resource Management Strategies

Land use planning is not conducted on a watershed-wide basis. Many agencies spend millions of dollars annually addressing urban runoff problems with very little interagency coordination even though downstream cities can be impacted by activities upstream. Solutions to managing urban runoff are closely tied to many interrelated resource management strategies including land use planning, watershed planning, water use efficiency, recycled water, protecting recharge areas, and conjunctive management.

Lack of Funding

The two main aspects of implementing urban runoff management measures are source control, including education, and structural controls. In highly urbanized areas, major costs include purchasing land for facilities and constructing treatment facilities. Local municipalities have limited ability to pay for retrofitting existing developed areas within existing budgets and there is a concern by some about the economic impacts of raising taxes and requiring residents and businesses to pay for retrofitting existing development.

Effects of Urban Runoff on Groundwater Quality

The movement of pollutants in urban runoff is a concern. Urban runoff contains chemical constituents and pathogenic indicator organisms that could impair water quality. The actual threat to groundwater quality from recharging urban runoff is dependent on several factors, including soil type, source control, pre-treatment, solubility of pollutants, maintenance of recharge basins, and depth to groundwater. Studies by USEPA (USEPA, 1983) and the U.S. Geological Survey (USGS, 1995) indicate that all monitored pollutants stayed within the top 16 centimeters of the soil in the recharge basins.

Nuisance Problems

Presence of standing water in recharge basins can lead to vector problems, such as mosquitoes and increasing concern related to the transmission of West Nile Virus.

Protecting Recharge Areas

Local land use plans often do not recognize and protect groundwater recharge and discharge areas. Areas with soil and geologic conditions that allow groundwater recharge should be protected where appropriate. Refer to the Recharge Areas Protection, Chapter 15 in Volume 2, for additional information.

Understanding

The general public and elected officials do not always understand the link between land use management and other resource management strategies and how home and business practices can affect nonpoint source pollution in waterways.

Recommendations to Promote Additional Urban Runoff Management

State

1. State agencies should coordinate their efforts to decide how the Five Year Implementation Plan for Nonpoint Source Pollution Program should be integrated into their workplans.

2. Encourage public outreach and education about the benefits and concerns related to funding and implementation of urban runoff measures.
3. Provide leadership in the integration of water management activities by assisting, guiding, and modeling watershed and urban runoff projects.
4. Work with local government agencies to evaluate and develop ways to improve existing codes and ordinances that currently stand as a barrier to implementing and funding urban runoff management.
5. Provide funding and develop legislation to support development of urban runoff and watershed management plans, enable local agencies and organizations to pursue joint venture, multipurpose projects, and collect information on regional urban runoff management efforts.
6. Assist agencies with developing recharge programs with appropriate measures to protect human health, the environment, and groundwater quality.
7. Work with federal policy makers and industry to create research and development incentives and to develop standards to reduce nonpoint source pollution from transportation related sources including lubricant systems, cooling systems, brake systems, tires, and coatings.

Local Agencies and Governments

8. Local agencies and governments should design recharge basins to minimize physical, chemical, or biological clogging, periodically excavate recharge basins when needed to maintain infiltration capacity, develop a groundwater management plan with objectives for protecting both the available quantity and quality of groundwater, and cooperate with vector control agencies to ensure the proper mosquito control mechanisms and maintenance practices are being followed.
9. When developing Urban Runoff Management Plans, local agencies and governments should:
   - Understand how land use affects urban runoff.
   - Look for opportunities to require features that con serve, clean up, and reduce urban runoff in new development, or in more established areas, when redevelopment is proposed.
   - Be aware of technological advances in products and programs.
   - Learn about urban runoff and watershed ordinances already in place. For example, The city of Santa Monica and the Fresno Metropolitan Flood Control District already have extensive urban runoff management programs in place.
   - Integrate urban runoff management with other resource strategies including land use planning, watershed planning, water use efficiency, recycled water, protecting recharge areas, and conjunctive management, and coordinate both within and across municipal boundaries.

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Volume 2

Chapter 22 Urban Water Use Efficiency

With urban water use efficiency, an increase in population does not necessarily result in a proportionate increase in urban water use. (J. Saare-Edmonds/ DWR photo)

Chapter 22 *Urban Water Use Efficiency*

Urban water use efficiency involves technological or behavioral improvements in indoor and outdoor residential, commercial, industrial and institutional water use that lower demand, lower per capita water use, and result in benefits to water supply, water quality, and the environment.

Urban Water Use Efficiency Efforts in California

In 2000, cities and suburbs used about 8.7 million acre-feet of water. Californians have made great progress on urban water use efficiency over the past few decades. As has been demonstrated in various regions of the state, an increase in population does not necessarily result in a proportionate increase in urban water use. For example, the Los Angeles Department of Water and Power reports in their Urban Water Management Plan Update 2002-2003 that "water conservation continues to play an important part in keeping the city's water use equivalent to levels seen 20 years ago." While some other regions of the State cannot claim such progress, this report indicates that indeed something is working well in the field of water use efficiency.

Credit for these improvements can be given in part to the implementation of water use efficiency practices that have been institutionalized through the California Urban Water Conservation Council's (CUWCC) Memorandum of Understanding (MOU). This involves the active participation and united effort of urban water agencies, environmental interests, and the business community. They come together to plan, implement, and track a defined set of urban Best Management Practices (BMPs See Box 22-1). As of 2003 there were 309 signatories to the Urban MOU, representing 80 percent of all the urban water supplied in California.

One example of the results of the CUWCC's member agency implementation efforts is that nearly 2.5 million water efficiency toilets have been retrofitted statewide in the past 13 years. The total number of toilets installed before 1992 that still need to be replaced is about 10 million. Water conservation has become a way of life for Californians, most of whom have easy and affordable access to a wide array of off-the-shelf water efficient plumbing fixtures, washing machines, landscape irrigation systems, and water-thrifty plants at their local home improvement stores, hardware stores, and nurseries.

Box 22-1 Urban BMPs

BMP 1: Residential Survey Programs
BMP 2: Residential Plumbing Retrofit
BMP 3: System Water Audits
BMP 4: Metering with Commodity Rates
BMP 5 Large Landscape Conservation
BMP 6: High Efficiency Clothes Washers
BMP 7: Public Information Programs
BMP 8: School Education Programs
BMP 9: Commercial Industrial Institutional
BMP 10: Wholesaler Agency Assistance Programs
BMP 11: Conservation Pricing
BMP 12: Conservation Coordinator
BMP 13: Water Waste Prohibitions
BMP 14: Residential Ultra Low Flush Toilet Replacement Programs

While the council is considering more BMPs, there are other activities that could contribute toward improved water use efficiency, including new methods and technologies that can be expected to significantly increase conservation potential. The Irvine Ranch Water District is experimenting with "ET Controllers" – weather-controlled irrigation systems and installed controllers at 40 homes. Consumption dropped by 17 percent and runoff was cut in half. The 1999 American Water Works Foundation Research Foundation "Residential End Uses of Water" study found that approximately 60 percent of residential water comes from outdoor uses.

Assembly Bill 2717, authored by Assemblyman John Laird and signed by Governor Arnold Schwarzenegger in 2004, asked the CUWCC to convene a Landscape Task Force with representatives from water suppliers, environmental groups, government agencies, and the landscape and building industries to evaluate landscape water use efficiency and make recommendations for improvements. The Landscape Task Force is currently evaluating in great detail the potential for water savings for both new and existing development. The recommendations of the Task Force may lead to significant improvements in landscape irrigation through new Model Landscape Ordinance policies, new technologies, changes in rate structures, and new legislation (See Box 22-2). The Task Force will finish its work and submit a final report to the California Legislature and governor by December 31, 2005.

Potential Benefits of Urban Water Use Efficiency

The primary benefit of improving water use efficiency is the lowering of demand and the ability to cost-effectively stretch existing water supplies. Once viewed and invoked primarily as a temporary source of water supply in response to drought or emergency water shortage situations, water use efficiency and conservation approaches have become a viable long-term supply option, saving considerable capital and operating costs for utilities and consumers, avoiding environmental degradation, and creating multiple benefits. Reduced water demands will free up water in normal and wet years. Saved water can be carried over to another time if a supplier has surface or groundwater storage, or stores water by agreement with an agency that maintains a groundwater bank and returns it for use during drought years. Translating water use efficiency savings into specific water supply reliability benefits will depend on the water system involved, the level of savings, and the variations in water savings from one year to the next as well as throughout the year.

The CALFED Record of Decision (ROD) estimated that applied water savings of existing urban water use efficiency efforts would range between 0.8 million and 1 million acre-feet per year by 2030 (CALFED Record of Decision, 2000). A recent state-sponsored study (Pacific Institute's "Waste Not, Want

Box 22-2 Draft Recommendation from Landscape Task Force

- Urban water suppliers (wholesalers and retailers) should adopt water conserving rate structures as defined by the Task Force
- Reduce the ET Adjustment Factor in the Model Ordinance and review the ET Adjustment Factor every ten years for possible further reduction.
- Enforce and monitor compliance with local ordinances and the state Model Ordinance including an enforcement mechanism to insure effective irrigation system installation and efficiency.
- Require dedicated landscape meters.
- Promote the use of recycled water in urban landscapes.
- Require that local ordinances be at least as effective as the State Model Ordinance.
- Increase the public's awareness of the importance of landscape water use efficiency and inspire them to action.
- Require Smart Controllers.
- Adopt and enforce statewide prohibitions on overspray and runoff.
- Provide training and certification opportunities to landscape and irrigation professionals.
- Support upgrading the California Irrigation Management Information System (CIMIS) Program.
- Adopt performance standards for irrigation equipment.

Table 22-1 CBDA Estimates of 2030 urban conservation savings potential (demand reduction)

Projection Level	Assumed Local Agency Investment	Assumed CALFED Grant Funding	(Demand Reduction by Category) 1,000 Acre-Feet Per Year			
			Required by Code	Local Agency Cost Effective	Grant Funded	Total Annual Potential
1	Historic Rate	Prop. 50 only	970	172	11	1,153
2	All Locally cost-effective	Prop. 50 only	970	881	11	1,862
3	Historic Rate mil./yr.	Prop. 50 + $15	970	172	257	1,399
4	All Locally cost-effective	Prop. 50 + $15 mil./yr.	970	881	257	2,108
5	All Locally cost-effective	Prop. 50 + $40 mil./ yr.(2005-2014); $10 mil./yr. (2015-2030)	970	881	224	2,075
6[1]	N/A	N/A	N/A	N/A	N/A	3,096

[1]Projection 6 represents the technical potential of the urban conservation measures evaluated by CBDA. It assumes 100% adoption statewide of these measures using existing technologies and provides a reference point for the other five projection levels.

Not") indicated potential savings of 2 million to 2.3 million acre-feet per year from existing urban conservation technologies and practices.

The California Bay Delta Authority (CBDA) sponsored a study of urban water conservation potential as part of its comprehensive review of the Water Use Efficiency Element of the CALFED Bay-Delta Program. This study evaluated urban water savings potential from three sources: (1) operation of efficiency codes that require certain water using appliances and fixtures to meet specified levels of efficiency; (2) local water agency implementation of urban conservation "Best Management Practices" (BMPs) specified in the Memorandum of Understanding Regarding Urban Water Conservation in California (Urban MOU) as well as other locally cost-effective conservation measures; and (3) additional urban conservation measures co-funded through CALFED Agency grant programs.

Estimates of urban savings potential were developed for six different projections. These projections employed different assumptions about local water agency implementation of conservation measures and funding levels for CALFED Agency grant programs. Two different levels of local water agency implementation of conservation measures were considered. The first level assumed implementation of BMPs would occur at the average rate of implementation observed during the first 13 years of the Urban MOU. The second level assumed that local water agencies would implement all BMPs and other conservation measures that were locally cost-effective from the perspective of the implementing agency. CALFED Agency grant program funding was evaluated at three levels. The first level assumed that grant program funding would consist only of remaining Proposition 50 funds available for urban conservation implementation. The second level assumed $15 million per year of funding for urban conservation implementation grants. The third level assumed $40 million per year of funding for the period 2005-2014 and $10 million per year for the period 2015-2030. These funding levels were selected to bracket the range of funding deemed probable at the time the study was undertaken. The sixth projection measured the water savings potential of the conservation measures under evaluation assuming 100% adoption and existing technologies. This last projection served as a reference point from which to evaluate the other five.

The CBDA estimates of 2030 urban conservation potential for the six projections are shown in Table 22-1. The estimates show the reduction in annual applied urban water use expected from each savings source as well as the total amount annual of savings. The technical potential, shown by projec-

Table 22-2 2030 Annual water savings potential by CBDA projections: recoverable and irrecoverable flows

Projection Level	Water Savings Potential 1,000 Acre-Feet Per Year		
	Irrecoverable Flow	Recoverable Flow	Total Savings Potential
1	729	423	1,153
2	1,285	575	1,862
3	818	578	1,399
4	1,375	729	2,108
5	1,368	702	2,075
6	1,980	1,110	3,096

tion 6, is about 3.1 million acre-feet per year. Advances in water-saving technology over the next 25 years, which the CBDA analysis did not evaluate, potentially could push savings beyond the levels shown in Table 22-1.

Total annual savings potential for projections 1 through 5 ranges between 1.2 million and 2.1 million acre-feet per year, or about 40% to 70% of technical potential. Water savings from efficiency codes, which include metering of currently unmetered connections, are significant, accounting for about 45% to 85% of total savings shown for projections 1 through 5. Water savings from local agency implementation are sharply affected by the assumed local investment. Potential savings are approximately five times greater if agencies are assumed to invest in all locally cost-effective measures than if they are assumed to invest at the historic rate of BMP implementation. Analysis results also show that continuing grant programs beyond Proposition 50 would approximately reduce water demand between 200,000 and 250,000 acre-feet per year by 2030.

Realization of a greater proportion of technical potential than shown by projections 1 through 5 would require higher rates of local and state/federal investment in urban conservation than considered by the CBDA analysis. Increasing BMP coverage requirements and higher levels of state/federal investment could allow the state to realize a greater amount of technical potential. However, achieving the technical potential savings may not be economical because of diminishing returns on investments.

The estimates in Table 22-1 represent changes in applied urban water use. This reduction in applied use includes both recoverable and irrecoverable flows. Recoverable flow is the portion of applied water that would return to a usable surface or groundwater body, making it available for reuse. Irrecoverable flow is the portion of applied water that would evaporate or return to an unusable surface or groundwater body and would not be available for reuse. Table 22-2 shows the annual recoverable and irrecoverable flows for the six projection levels.

Reducing both recoverable and irrecoverable flows, or urban applied water, through conservation can benefit urban water users. In either case, costs associated with water development, transmission, treatment, storage, distribution, and disposal can be avoided, which can benefit urban ratepayers. Reducing both types of flow may also result in increased stream flows and water quality benefits. Reducing irrecoverable flows through conservation has the added benefit of increasing the amount of developed water available for human uses at no added cost to other users or the environment.

Realizing the conservation potential shown in Table 22-1 offers water agencies immediate and longer-term benefits in the form of avoided costs of new supply construction, the cost of distribution systems, and the avoided costs of water-supply treatment and wastewater treatment plant permitting, construction and operation. Energy costs, which are a significant component of water costs, are avoided as well, both by the agency and the customer. The California Energy Commission estimates that nearly one-fifth of the state's energy use is associated with water development and use. Urban water conservation can help stretch the state's energy supplies as well as its water resources. Other benefits of urban water use efficiency include better water quality and more water in streams and rivers by allowing more flows to remain there. The timing of such additional flow is often critical to maintenance of endangered habitats. Water use efficiency can also reduce peak demand, curb runoff from landscape irrigation, and reduce green waste caused by inefficient watering of landscape.

Table 22-3 Statewide average unit cost of water savings by CBDA projection (2004 dollars)

Projection Level	Assumed Local Agency Investment	Average Unit Cost of Water Savings Per Acre-Foot
1	Historic Rate	$522
2	Locally cost-effective	$223
3	Historic Rate	$395
4	Locally cost-effective	$227
5	Locally cost-effective	$233
6	A unit cost for projection 6 was not developed by CBDA because of uncertainty about how implementation costs would change as measure adoption rates approached 100%.	

One way to assess the financial benefits of a conservation measure is to compare the cost of producing an acre-foot of water savings from this measure to the cost of acquiring one more acre-foot of supply. This approach acknowledges that there are essentially two, and often compatible, approaches water agencies can use to meet their water demand. They can increase supplies and lower demands. Ratepayers benefit when water agencies use an integrated resource planning (IRP) approach to invest in the mix of supply- and demand-management strategies capable of meeting agreed-to resource management objectives with the lowest overall cost and impacts.

Potential Costs of Urban Water Use Efficiency

The average cost (in 2004 dollars) to realize an acre-foot of water savings for CBDA projections 1 through 5 are shown in Table 22-3. Costs range from $223 per acre-foot to $522 per acre-foot. The assumed local investment has a significant impact on the average costs. The average costs for projections that assume water agencies invest in all locally cost-effective conservation measures are approximately 40% to 60% lower than the other projections. It is important to note that the cost estimates in Table 22-3 are statewide averages and results for individual regions or water agencies could vary significantly.

Conservation's role in urban water management depends on a variety of regional and local considerations that are best addressed through an integrated resources planning framework. The unit costs in Table 22-3 suggest, however, that for most urban areas conservation will likely become an increasingly important part of their water resource management. The unit costs in Table 22-3 are currently lower than other urban supply options such as recycling, desalination, or new surface water development. The State Recycled Water Task Force, for example, estimated that California could achieve the Task Force's recycled water objectives at an average cost of $600 per acre-foot. A similar task force examining ocean desalination estimated average costs $661 to $834 per acre-foot, not inclusive of cost of delivery to the customer. Because conservation investments generally reduce customer end uses of water, the average costs shown in Table 22-3 are equivalent to a cost to deliver treated water to the customer tap.

The Record of Decision for the CALFED Bay Delta Program assumed that the average cost of urban conservation measures would be between $150 and $450 per acre-foot. CBDA's analysis of urban conservation potential suggests somewhat higher average costs, ranging, when rounded, between $220 and $530 per acre-foot. Both estimates indicate that investment in urban conservation can be a very cost-effective strategy for addressing growing urban demand for water.

Table 22-4 presents CBDA estimates of annual investment over the period 2005-2030 needed to realize the conservation savings shown for projections 1 through 5 in Table 22-1. Annual investment costs range between $99 million and $236 million. This investment is of three types: (1) direct investment by water agencies in locally cost-effective conservation measures; (2) investment by CALFED Agencies through grants; and (3) additional investment by water agencies leveraged by grants from CALFED Agencies. Approximately 60% to 90% of the annual investment costs shown in Table 22-4 are of the first type. The remaining 10% to 40% of investment comes from grants and grant-leveraged local investment.

Table 22-4 CBDA estimates of 2030 urban conservation savings potential (demand reduction)						
Projection Level	Local Agency Investment Assumption	CALFED Grant Funding Assumption	Annual Investment Cost ($ Millions per year)			
			Local Direct Investment	Grants	Grant-leveraged Local Investment	Annual Investment
1	Historic Rate	Prop. 50 only	95	3	1	99
2	Locally cost-effective	Prop. 50 only	188	3	1	192
3	Historic Rate	Prop. 50 + $15 mil./yr.	95	37	11	143
4	Locally cost-effective	Prop. 50 + $15 mil./yr.	188	37	11	236
5	Locally cost-effective	Prop. 50 + $40 mil./yr. (2005-2014); $10 mil./yr. (2015-2030)	185	35	16	236
6	The annual cost for projection 6 was not developed by CBDA because of uncertainty about how implementation costs would change as measure adoption rates approached 100%.					

Major Issues Facing Additional Urban Water Use Efficiency

Funding

Funds dedicated to water use efficiency have fallen below commitments made in 2000 through the CALFED Record of Decision that called for a state and federal investment of $1.5 billion to $2 billion during Stage 1 from 2000-2007. For example, by 2002, investments lagged projected expenditures by $4 million. By 2003, investments lagged projected expenditures by $235 million.

Through the CUWCC MOU, local agencies have committed to funding locally cost-effective BMPs. State and federal programs have also provided funding for the BMPs beyond the MOU level for actions that may not be locally cost effective. A consistent and broadly acceptable method to evaluate cost-effectiveness and water savings has been developed by the CUWCC. A publication describing cost effectiveness and spreadsheets that calculate cost effectiveness by BMP have both been created, and are posted on the Council's web site. A water savings model has also been created and is embedded into the Council's BMP Reporting database. The results are publicly viewable at www.bmp.cuwcc.org.

Additional research is needed into the problems of funding and implementing the water conservation programs. One approach to funding programs is a no-interest revolving loan program that could provide funds to urban water suppliers based on the avoided cost of new supply alternatives. Once the loan is repaid, all future savings will accrue to the supplier and its customers. One example of a no-interest loan program is the "Unconserved Water Using Air Conditioner Replacement Program" established by the city of Fresno. The program made customers with water using air conditioners, who paid a surcharge based on the estimated water use of the devices, eligible to replace them with new non-water using energy efficient units. It applied the surcharge paid by participating customers to loan repayment for the program. The customer surcharge will be eliminated when the no-interest loan is repaid.

This research should include innovative mechanisms similar to those used by performance based contractors in the energy field. One example is the Light Wash Program in which a company is working with California water agencies and utilities to offer combined energy and water conservation rebates of up to $450 per unit on a wide selection of high efficiency commercial clothes washers. The company offers rebates to multifamily and institutional common area laundry facilities, businesses with on-premise laundry, and coin laundry stores in 2003. The program is operated on a turnkey basis for participating water utilities and requires virtually no staff time. The only required contribution by participating water utilities is the rebate co-payment. Program participation is available to water utilities whose customers are also customers of three energy utilities. The program is being implemented with funding from California energy utility ratepayers under the auspices of the California Public Utilities Commission.

Grant programs often miss the opportunity to fund worthwhile projects in small and disadvantaged communities. It is often difficult for them to compete for limited grant funds, although their needs are often great.

Program Implementation

An expanding population, climatic uncertainties, contaminants, and legal and economic conditions likely will increase the pressure to improve the efficiency of water use in California. While the CUWCC Best Management Practices have provided an effective way for agencies to identify and implement locally cost effective urban water conservation programs, not all water suppliers have signed on to the agreement and not all of the signatories are fully implementing those practices.

There are a number of challenges faced by agencies when implementing urban water conservation programs. A recent study sponsored by California Urban Water Agencies identified a number of these implementation challenges for urban water conservation programs (See Table 22-5).

The CUWA sponsored study recommends collaborative action by agencies, further research, and continued State/federal support in addressing the implementation challenges. CUWA study concludes that the program should be as easy as possible for customers, its design should be simple, it should provide customers with guidance on water efficient fixtures, it should be coordinated with other agencies regarding permitting or potential funding, and emphasize a high level of customer service.

Data Collection

Easily retrievable, standardized and comprehensive baseline data about California urban water use are not available. Present information sources include annual Public Water System Survey (PWSS) reports to DWR, annual CUWCC BMP Reports submitted by MOU signatories, and Urban Water Management Plans that are updated every five years. Documentation and evaluation of the achievements attributable to water use efficiency projects and programs, vital elements of successful water use efficiency efforts, need to be improved. The quantification of benefits for many projects lacks the necessary level of scientific rigor. The basis for making such determinations and managing water efficiently is accurate water measurement, coupled with volumetric billing, complemented by ongoing accounting, monitoring and assessment.

The measurement of water use and associated information provided to the water user are essential to efficient water management. Documenting water savings related to the various programs rests on the ability to track water use. Most urban areas are metered, but several metropolitan areas, mostly in the Central Valley and Foothill regions, remain unmetered. DWR staff estimates that about 700,000 water users remain unmetered.

Both of these endeavors are necessary to gain an accurate understanding of the full cost, value, impact and direction of urban water use efficiency strategies.

Education and Motivation

Likewise, there is a need for information related to why Californians adopted water use efficiency practices and how those practices could be encouraged and continued. Also, there is need to determine how customers or water districts respond to financial incentives. Which technological changes should be pursued for short-term situations (during water shortages) compared to long-term, and which behavioral changes are most effective short and long term?

Innovation

Emerging water conservation technologies and techniques offer new opportunities to save water, but often field-testing and evaluations are needed before being promoted and fully adopted. Presently it takes too long to run pilot projects, conduct research, and provide the sound scientific data needed by agencies and consumers to adopt new behaviors or purchase new equipment.

Conservation Offset refers to the actions that urban water suppliers take where a developer, in order to obtain approval for a proposed project, must implement, or financially contribute to, actions that will save water at or above the demand level of the project. Developers have installed or paid for the retrofit installation of dual flush toilets, low flush toilets, high efficiency clothes washers, Xeriscape residential landscaping, water efficient landscaping on common area and street medians, ET irrigation controllers, artificial turf, use of recycled water for all large turf irrigation, hot water recirculation demand systems, pre-rinse spray valves, and even farm irrigation improvements. Offset programs in Cambria, on the California coast, have included farm irrigation improvements such as drip irrigation. Some water districts implementing an Offset program require the developer to implement actions that save two or more times the projected water demand for their projects. As a result, some communities with limited water supplies have been able

Table 22-5 Urban water conservation implementation challenges	
Program Type	**Implementation Challenges**
Residential indoor	Marketing; incentives; communication barriers
Residential outdoor	Persistence of water savings; follow-up visits; communication barriers
Public information	Difficult to quantify water savings; communication barriers; need to update information on a regular basis
Commercial, industrial and institutional	Lack of reliable savings estimates; lack of adequate in-house technical skills; resistance to changes in a process that works; communication barriers; low water costs make water conservation a low priority for some businesses
Large landscape	Incentives (the hand on the spigot may not pay the bill); persistence of water savings; communication barriers
Targeting public entities	Incentives (some public entities do not directly pay for the water),school's lack of funding inhibits participation
Plumbing code	Lack of coordinated effort to revise the standards
Water rates/efficiency pricing	High risk local political issue
Leak detection	High expense of leak detection; requirements for retrofit or rehabilitation

to permit some growth while reducing their net water needs. Water savings have been achieved using the Offset program in the city of San Luis Obispo (2 acre-feet of retrofit water savings required for each new acre foot of demand, a 2:1 Offset), Cambria (7-8% less water use per year), Ojai (3:1 Offset).

While an Offset program can be a useful part of a tool kit for water supplier's conservation actions, the concept has not been widely used despite its successes. However, the requirements for documenting a reliable water supply over a 20-year period created by Senate Bill 610 and Senate Bill 221 may create an incentive for developers to implement voluntary Offset programs in order to create new water supplies for their projects.

Recommendations to Achieve Additional Urban Water Use Efficiency

In addition to the BMPs, the following actions reflect some of the possible solutions to the issues raised in the previous section. A wide range of strategies will need to be employed to accomplish the actions including financial incentives; revisions in State and local codes and standards; and legislative initiatives. Most of these will be cooperative efforts, involving State, federal, and local agencies and stakeholders and California citizens.

1. The State should secure funding to support incentive programs, both implementation and data collection. Identify and establish priorities for future grant programs and other incentives. Provide ample opportunities for small districts, economically disadvantaged communities to benefit from WUE incentive programs.
2. Work with CUWCC and others to encourage and help local agencies and governments in fully developing, implementing and sustaining water conservation programs. Develop and implement rate structures that encourage water use efficiency. Help water customers perform leak detection and repair on a regular basis. Employ recycled water whenever feasible for landscape, industrial, and other approved uses. Encourage the plumbing of new construction for the use of non-potable water.
3. Consider how to irrigate landscapes efficiently, reduce urban runoff, improve fire safety, and mitigate "heat island effects" through landscape design, installation, management and maintenance practices such as grouping plants with similar water use requirements, irrigation scheduling, landscape audits, dedicated irrigation meters, weather driven timers, etc. The State should provide technical assistance to the California Urban Water Conservation Council and urban water suppliers to create "California Friendly Landscapes©," those that attain maximum water use efficiency by applying the minimum amount of water necessary to sustain them through the design, installation, management, and maintenance of landscape material. The State should support the recommendations of the AB 2717 Landscape Task Force convened in 2005 by the CUWCC. The Task Force will (1) make recommendations for improving the Model Landscape Ordinance, and (2) comment on additional matters related to landscape water use efficiency. Consider

use of graywater systems where conditions permit and cistern systems to capture storm water where appropriate.

4. Develop collaborative efforts to:
   - Work with builders, manufacturers and others to establish a "Water Star Homes" program for new and existing homes and performance standards for fixtures and appliances, reducing residential water use.
   - Retrofit remaining standard toilets with more efficient models, such as dual-flush toilets or 1.0 gallon-per-flush toilets.
   - Use hot-water-on-demand systems in new residential construction
   - Pursue best available technology and management practices in the commercial, industrial, and institutional sectors.
   - Retrofit standard urinals with more efficient models.
   - Encourage the formation of employee/management "Green Teams" in commercial, industrial and institutional customers to promote sustainable resource use.
   - Encourage dry cooling for power plants.
   - Provide comprehensive public information, education, training, and technical assistance programs to foster a strong environmental resource ethic with an emphasis on water use efficiency.
   - Coordinate with other resource management programs such as watershed management, urban runoff management,waste water treatment, and green waste reduction.

5. Consider data, research, and monitor needs to inform decisions on:
   - Support metering of all urban customers and bill by volume of use, submeter new multifamily residential construction.
   - Encourage development of incentives for use of submeters in large landscape irrigation.
   - Employ scientific methods to research, monitor, and evaluate existing and new water use efficiency technologies and management practices, including the positive and potentially negative effects of these practices and real world challenges to implementation.
   - Increase the emphasis on the science aspect of projects, especially monitoring and evaluation, in support of CALFED goals.
   - Work with State and federal grant recipients and others to obtain more useful and consistent data from funded projects and other activities, including the documentation of the sources of data and the methods of data collection.
   - Encourage comprehensive planning and implementation of water conservation activities at the local and regional level. Pursue and promote state or local policies, guidelines, ordinances, or regulations to affect positive change.
   - Encourage more signatories to the CUWCC Memorandum of Understanding and full participation by present signatories.
   - With the leadership of the CUWCC and participation of other stakeholders, standardize utility billing and reporting systems by customer type and units of measure and identify industrial water use customers by North American Industry Classification System (NAICS). Collect end-use data periodically. Coordination of water use reports and the use of a web-based format for reporting could also improve data collection and exchange. Support uniform water use reporting.
   - Gain more information through surveys and other methods to better understand how Californians use water and how to persuade them to adopt more efficient practices and behaviors. Establish a goal for per capita water use in California.

Box 22-3 Demand Hardening

Most water use efficiency programs rely on plumbing and appliance retrofits and changes in the consumer's water use that can take place on a consistent, predictable basis. Once most of these retrofits have been completed, some worry that their ability to further reduce water use during dry years will be limited. This phenomenon is known as "demand hardening". Districts and customers that have participated actively in water conservation programs fear that across-the-board cuts will affect them disproportionately. However, consumers will still respond behaviorally in drought times, and this additional water savings from the drought response can be measured using daily production records. Public education has proven effective in rallying support for short-term additional water conservation measures.

6. Develop community based social marketing surveys and strategies for conservation activities to foster water use efficiency, with the participation of the water industry, environmental interests, and the business communities. Identify and overcome barriers, communicate the benefits, provide incentives, and gain commitment from all involved.
7. Explore and identify innovative technologies and techniques to improve water use efficiency and develop new BMPs to correspond with new information. Fast track pilot projects, demonstrations, and model programs exploring state-of-the-art, water-saving technologies and procedures and publicize results widely.
8. State should prepare guidelines to assist water districts who are interested in implementing the Conservation Offset.
9. Some innovative Offset techniques need to be developed for urban landscaping savings.
10. State should encourage building trade associations promote the Offset concept.

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Volume 2

Chapter 23 Water Transfers

Water transfer is a voluntary change in the way water is usually distributed among water users in response to water scarcity. In practice, many water transfers become a form of flexible system reoperation linked to many other water management strategies. (DWR photo)

Chapter 23 *Water Transfers*

A water transfer is defined in the Water Code as a temporary or long-term change in the point of diversion, place of use, or purpose of use due to a transfer or exchange of water or water rights.[1] Many transfers, such as those among contractors of the State Water Project or Central Valley Project, do not fit this definition. A more general definition is that water transfers are a voluntary change in the way water is usually distributed among water users in response to water scarcity. Transfers can be from one party with extra water in one year to another who is water-short that year.

Transfers can be between water districts that are neighboring or across the state, provided there is a means to convey and store the water. Water transfers can be a temporary or permanent sale of a water right by the water right holder; a lease of the right to use water from the water right holder; or a sale or lease of a contractual right to water supply. Water transfers can also take the form of long-term contracts for the purpose of improving long-term supply reliability. Generally, water is made available for transfer by five major sources:

1. Transferring water from storage that would otherwise have been carried over to the following year. The expectation is that the reservoir will refill during subsequent wet seasons.
2. Pumping groundwater instead of using surface water delivery and transferring the surface water rights.
3. Transferring previously banked groundwater either by directly pumping and transferring groundwater or by pumping groundwater for local use and transferring surface water rights.
4. Making water available by reducing the existing consumptive use through crop idling or crop shifting or by implementing water use efficiency measures.
5. Making water available by reducing return flows or seepage from conveyance systems that would otherwise be irrecoverable.

Water transfers are sometimes seen as merely moving water from one beneficial use to another. However, in practice many water transfers become a form of flexible system reoperation linked to many other water management strategies including surface water and groundwater storage, conjunctive management, conveyance efficiency, water use efficiency, water quality improvements, and planned crop shifting or crop idling. These linkages often result in increased beneficial use and reuse of water overall and are among the most valuable aspects of water transfers. Transfers also provide a flexible approach to distributing available supplies for environmental purposes.

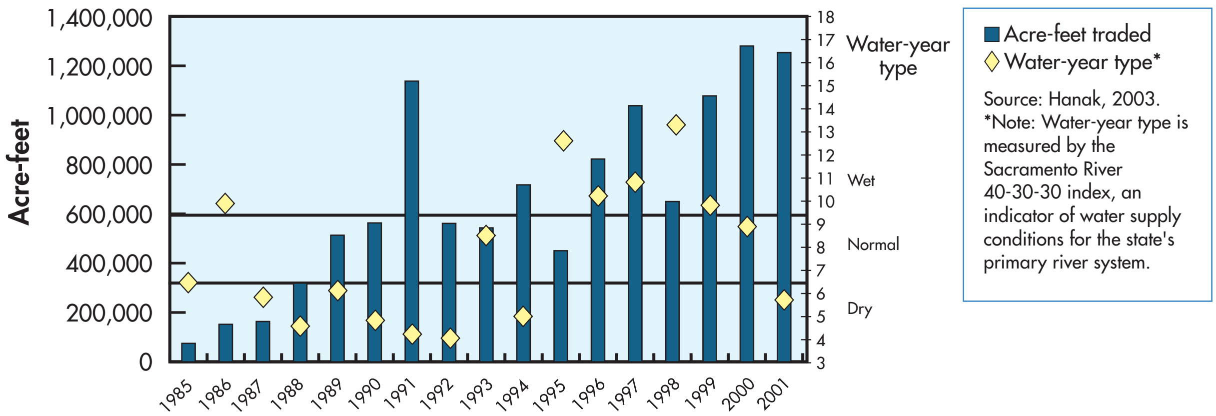
Water Transfers in California[2]

Statewide, water transfers have significantly increased since the mid-1980s. Temporary and long-term transfers between water districts increased from 80,000 acre-feet in 1985 to over 1,250,000 acre-feet in 2001 (see Figure 23-1). About 80 percent of this volume is traded on a short-term basis, within the same year. The remaining 20 percent is considered long-term, for durations ranging from two to 35 years. Since 1998, there have been several permanent transfers of water rights and contracts with the Central Valley Project and the State Water Project for up to 175,000 acre-feet per year.

[1] Temporary water transfers, Section 1728 of the California Water Code, have a duration of one year or less. Long term water transfers, Section 1735 of the California Water Code, have a duration in excess of one year.

[2] Data in this section are drawn from Chapter 2 and Appendix A of *Who Should Be Allowed to Sell Water in California? Third-Party Issues and the Water Market,* Public Policy Institute of California, 2003. Ellen Hanak. (available for download at www.ppic.org). These data do not include transfers between farmers within the same water district, which can be substantial in some places.

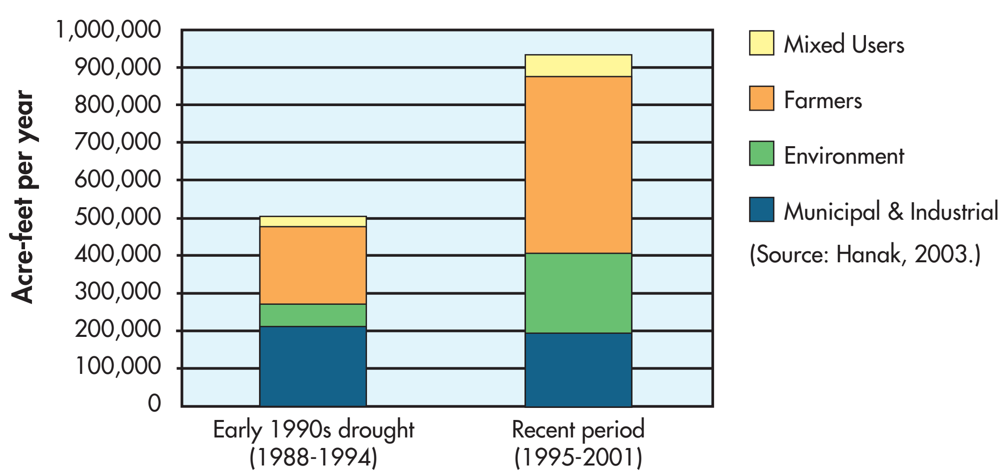
Figure 23-1 Temporary and long-term water transfers in California



Temporary and long-term transfers between water districts have increased from 80,000 acre-feet in 1985 to more than 1,250,000 acre-feet in 2001. About 80 percent of this is traded on a short-term basis, within the same year. The remaining is considered long-term, for durations from 2 to 35 years.

Statewide water conditions have encouraged water transfers as a management strategy. Transfer activity increased substantially during the drought of the late 1980s and early 1990s, especially through the State-run Drought Water Bank and other drought-related State and federal programs. Transfers continued to increase since the mid 1990s, generally a much wetter period. Throughout this period, water transfers have primarily been from agricultural water districts, although in some wet years urban districts in Southern California have also transferred water to other users. The pattern of transfers changed somewhat between the prolonged drought in the early 1990s and the more recent period (Figure 23-2). Although urban water districts were a primary destination in the early 1990s, accounting for over 40 percent of all transfers, their transfers have remained flat since the mid 1990s and now account for only 20 percent of all purchases.

Figure 23-2 Water transfer by type of end-user



The pattern of transfers changed somewhat between the prolonged drought in the early 1990s and the more recent period. Two sectors responsible for most growth in transfers have been environmental programs and agriculture. Transfers to urban users have remained flat since the mid-1990s.

Two sectors responsible for most growth in transfers have been environmental programs and agriculture. Environmental purchases to benefit wildlife refuges and instream fish populations began during the early 1990s drought. They have increased considerably under the Central Valley Project Improvement Act and CALFED's Environmental Water Account, accounting for roughly 25 percent of the total volume of transfers since 1995 and as much as one-third by 2001. Agricultural districts now account for half of all transfers, and have been responsible for two-thirds of growth in transfers since 1995. The bulk of this increase is destined for farmers in the San Joaquin Valley and Tulare Basin, who have turned to transfers for replacement water in response to cutbacks of contract allocations under the Central Valley Project Improvement Act. Typically, farmers purchase water on a year-to-year basis. Most long-term and permanent transfers are destined for urban users.

Three regions are major participants in water transfers: the 10-county Sacramento Valley, the eight-county San Joaquin Valley and Tulare Lake Basin, and the seven-county Southern California region.[3] In most years, roughly 75 percent of transfers (by volume) originate within the Sacramento and San Joaquin valleys, with the remainder from Southern California. Overall, most transfers are between users within the same county (nearly 25 percent) or within the same region (nearly 50 percent). Interregional transfers account for the remaining 25-30 percent of transfers. Only 20 percent of these transfers are negotiated directly between parties in different regions; the rest move through programs run by DWR and USBR.

Oversight of Water Transfers in California

Before the Drought Water Bank program, water transfers were usually arrangements between two parties, one with extra water and one with unmet water demands. These parties would reach a mutually acceptable arrangement regarding price and quantity. Because public rights in water have always been recognized, approval by appropriate State and federal agencies has been viewed as a necessary part of the process for these water transfers. Transfers which involve changes in place or purpose of use of permitted or licensed water rights most often require the approval of the State Water Resources Control Board. Transfers which require the use of State or federal facilities or which may affect project operations require the concurrence or approval of DWR or USBR. State water law generally requires that transfers not damage any other legal user of water, not unreasonably affect fish and wildlife, and not unreasonably affect the overall economy of the county from which the water is transferred.[4] State agencies must consider the effects on public trust resources when participating in or approving water transfers.

The Drought Water Bank, Dry Year Purchase Programs, Environmental Water Account (EWA), and Central Valley Project Improvement Act have increased the role and responsibilities of State and federal agencies in the water transfer process. A large portion of water transfers each year now occur either under the guidance of, or funded by, a State or federal program. The complexity of cross-Delta transfers and the need to optimize the use of both CVP and SWP facilities make USBR and DWR critical players in the water transfer process. The rules that govern water transfers within the SWP or CVP typically protect water users within these projects from the potential adverse effects of water transfers made by other project users.

The EWA is an element of the CALFED Bay-Delta Program's overall Management Strategy for the Bay-Delta Ecosystem that is administered, managed, and implemented by five federal and State agencies (U.S. Bureau of Reclamation, California Department of Water Resources, U.S. Fish and Wildlife Service, National Marine Fisheries Service, and California Department of Fish and Game). EWA's purpose is to provide protection to the fish of the Bay-Delta Estuary through environmentally beneficial changes in the operations of the CVP and SWP at no uncompensated water cost to the projects' users. EWA reduces Delta exports or provides other modifications to CVP and SWP operations at critical times for added protection to at-risk native fish species above that provided by the existing regulatory baseline. These changes in operations can cause reductions in water supply to users

[3] Data availability allows regional definitions for county groupings, but not DWR's hydrologic regions. Notably, Southern California includes both the South Coast and Colorado River hydrologic regions (Imperial, Los Angeles, Orange, Riverside, San Bernardino, San Diego, and Ventura counties), and the San Joaquin Valley includes both the San Joaquin River and Tulare Lake hydrologic regions (Fresno, Kings, Kern, Madera, Merced, San Joaquin, Stanislaus, and Tulare counties). Sacramento Valley includes Butte, Colusa, Glenn, Placer, Sacramento, Shasta, Sutter, Tehama, Yolo, and Yuba counties.

[4] California Water Code Section 1810 *et seq.* specifies the requirements that must be met in order for DWR and other regional and local agencies to allow use of their conveyance facilities. Also, Water Code Sections 386, 1702, 1706, 1727 and 1736 follow the common law and establish similar requirements for changes in water rights. Strictly speaking, economic issues are typically only required to be evaluated in water transfers that seek to utilize DWR's water conveyance facilities or those of other State or local agencies. However, economic impacts that are associated with physical changes to the environment may require analysis under the California Environmental Quality Act (CEQA).

south of the Delta. Therefore, EWA obtains water to replace the project water not delivered to CVP and SWP contractors in the Delta export service areas caused by these changes in CVP or SWP operations.

Enactment of the Central Valley Project Improvement Act (CVPIA) in October 1992 provided new authority and expanded flexibility to U.S. Bureau of Reclamation to allow transfers of federally developed water. One purpose of the CVPIA is to improve CVP operational flexibility and increase water-related benefits provided by the CVP through expanded use of voluntary water transfers. The water transfer provisions of the CVPIA govern the transfer of CVP water and establish the conditions under which CVP water can be transferred. These provisions authorize CVP users to transfer, subject to certain conditions, all or a portion of their CVP contract water to any California water user or agency, State or federal agency, Indian tribe or private nonprofit organization for any purpose recognized as beneficial under State law. CVPIA does impose additional fees on CVP water being transferred to non-CVP contractors and from agricultural use to urban use, including an additional $25 per acre-foot (October 1992 price levels) surcharge for CVP water transferred for municipal and industrial purposes to anyone who previously has not been a CVP customer; however, such additional revenue is deposited in the CVPIA Restoration Fund and used only to implement environmental restoration activities within the Central Valley.

Controversy regarding the effects on water users, fish and wildlife, and local economies strained the Drought Water Banks of the early 1990s. In response, DWR and USBR developed guidelines for implementing water transfers conducted within their areas of responsibility (Box 23-1). The purpose of the guidelines is to help resolve issues and clarify the technical aspects of water transfers that need consideration when contracting with these agencies to either sell or convey water made available through water transfers.

In addition, DWR and water districts in Northern California have begun to develop better mechanisms to respond to concerns over potential transfer effects on local water users and the environment. Cooperative monitoring and rapid response programs have been implemented to identify and protect or mitigate potential impacts on groundwater levels from groundwater substitution programs. Data from monitoring programs and open communication with parties that could be affected have helped identify groundwater issues as they developed and before adverse impacts became serious. Districts took actions to halt pumping, deepen wells, and work with parties that could be affected to prevent or mitigate impacts caused by water transfers.

Local leadership and initiative are also needed to implement water transfers. Water transfers are typically proposed by local water agencies and can benefit from local community involvement in the development of these proposals. Some counties have passed local ordinances to regulate groundwater extraction for water transfer purposes. With adequate public notice, disclosure of proposals and meaningful public participation, local communities can best assess their area's water demands and supplies and determine if there is potential for transferring water outside of the local region.

An example of local leadership in implementing water transfers is the December 1988 Water Conservation Agreement (Agreement) between Imperial Irrigation District (IID) and Metropolitan Water District of Southern California (MWD) and in the December 1989 Approval Agreement among IID, MWD, Palo Verde Irrigation District and Coachella Valley Water District. The Agreement provided for water conservation from 17 projects to be constructed by IID under the Program. Projected water conservation, when the final project was placed into operation, was 106,110 acre-feet of water per year. MWD funded all costs of the new projects in return for having this additional amount of Colorado River water available for diversion through its Colorado River Aqueduct.

The Agreement called for a Program Coordinating Committee (PCC) to secure effective cooperation and interchange of information and to provide consultation, review, and approval on a prompt and orderly basis between IID and MWD in connection with various financial, economic, administrative, and

Box 23-1 DWR and USBR Water Transfer Guidelines

- DWR has published water transfer guidelines in a series of white papers available on DWR's Water Transfers Office Web site www.watertransfers.water.ca.gov
- USBR, upon enactment of CVPIA, issued "Interim Guidelines for the Implementation of the Water Transfer Provisions of Central Valley Project Improvement Act", available from USBR's Water Transfer Program office.

Table 23-1 Pending or approved long-term water transfers[1,2]

Seller	Buyer	Maximum Annual (Acre-feet)	Duration (years) (from/to)	Purpose
Imperial ID	San Diego County WA	200,000	35-75	Agriculture to Agriculture and Urban (QSA)
Imperial ID	Coachella Valley WD	103,000	35-45	Agriculture to Agriculture (QSA)
Imperial ID	Coachella Valley WD	50,000	46-75	Agriculture to Agriculture (QSA)
Imperial ID	Metropolitan WDSC	110,000	54 years or 60 years + 210 days or 90 years + 210 days	Agriculture to Urban (QSA)
Imperial ID	QSA Joint Powers Authority (through San Diego County WA) for Salton Sea Mitigation Program	150,000	maximum of 15	Agriculture to Environment (QSA)
Butte WD	Madera ID and Root Creek WD	15,000	25	Agriculture to Urban
Merced ID	U.S. Fish and Wildlife	47,000	10	Agriculture to Environment
Palo Verde ID	Metropolitan WDSC	111,000	35	Agriculture to Urban
South San Joaquin ID	Cities of Tracy, Escalon, Manteca, and Lathrop	75,000	25	Agriculture to Urban

1 Data in this table are from the Colorado River Quantification Settlement Agreement and Table A.5 of Ellen Hanak, *Who Should Be Allowed to Sell Water in California? Third-Party Issues and the Water Market*, Public Policy Institute of California, 2003 (available for download at www.ppic.org). These data do not include transfers between farmers within the same water district, which can be substantial in some places.

2 Water transferred under the QSA will not result in new water for California; rather it is a step to having California water users reduce their use of Colorado River water by 800,000 acre-feet per year – from 5.2 million acre-feet to California's apportionment of 4.4 million acre-feet per year plus 50 percent of any declared surplus.

technical aspects of the Program. The Approval Agreement called for a Water Conservation Measurement Committee (WCMC) to provide an orderly basis, among the parties, for verification of the amount of water conserved and different amounts conserved by the individual projects. All program actions of the PCC are to be approved by a majority vote. WCMC decisions, however, are to be approved by unanimous vote. If unanimity is lacking, the matter is taken up according to a dispute resolution procedure in the Approval Agreement.

Potential Benefits of Water Transfers

For receiving areas, water transfers have the potential of improving economic stability and environmental conditions that can deteriorate with water scarcity. Sellers can use the compensation from transfers to fund beneficial activities, although there is no guarantee that benefits to the seller will benefit the source area as a whole. Compensation from most transfers involving agricultural water goes directly to the participating landowner, who may choose to reinvest into the farming business. In some cases, compensation goes to water districts, which can use the income to reduce water rates, improve facilities, or improve environmental conditions. For example, Western Canal Water District used proceeds from drought water bank sales to remove diversion dams and reconfigure its canals to reduce impacts on threatened spring-run salmon. Transfers by regional water agencies can provide additional resources to benefit the entire community. For example, the Yuba County Water Agency has used over $10 million from the proceeds of water transfers over the past several years to fund needed flood control projects.

In addition to the approximately 1.2 million acre-feet transferred annually in recent years, there are several long-term transfers pending or approved since 2003 shown in Table 23-1. These include transfers under the Colorado River Quantification Settlement Agreement (QSA). Beyond those transfers shown in Table 23-1, economic studies indicate that about 300,000 acre-feet in the Sacramento Valley and 400,000 acre-feet in the San Joaquin Valley could be made available through crop idling without unreasonably affecting the overall economy of the county from where the water would be transferred.[5] These studies estimate that the economic effects of idling up to 20 percent of the rice

5 Studies conducted for the Final EIS/EIR for the Environmental Water Account dated January 2004.

land in the Sacramento Valley and up to 20 percent of the cotton lands in the San Joaquin Valley in any given year are near 1 percent or less of the countywide economy, except in Glenn and Colusa counties where the impact would be less than 5 percent of the countywide economy. The amount of land that would be idled is less than 10 percent of the total agriculture lands in these counties. The studies did not evaluate the economic effects of crop idling on commodity markets.

A statewide economic-engineering optimization study by the University of California, Davis (Jenkins, et al. 2001; Newlin et al. 2002) highlights potential benefits of water transfers to meet forecasted future water scarcity. Results suggest that by 2020 water transfers combined with conjunctive management and various operational changes could provide additional economic benefits as high as $1.3 billion per year statewide by reducing forecasted economic impacts of water scarcity as much as 80 percent. Almost all of the benefit comes from intra-regional water transfers and operational improvements within five regions of California, especially in Southern California. The study indicates that the maximum reduction in deliveries to a major seller of water would be 15 percent with most transfers averaging a much smaller reduction in deliveries to sellers of water. The study concludes that only a small proportion of California's water need be transferred to achieve significant economic benefits. Much of the added benefits would be from increased flexibility added to the water management system through reoperation of surface water and groundwater supplies using conjunctive management. The results of this study represent a simplification of California's water management system and do not address legal and institutional barriers that may prevent full implementation.

Potential Costs of Water Transfers

The direct costs of completing a water transfer include more than just the sale price of water, which is typically based on the last point the seller controls the water. Additional direct costs to the buyer include conveyance, storage, and treatment costs. Sale prices reflect the cost to make the water physically available and, in some cases, added monitoring or mitigation needed to ensure compliance with federal and State legislative guidance related to water transfers. The buyer typically arranges for transferred water to be conveyed to their area of use. Conveyance costs can be significant, as much as the price paid to the seller. For example, prices paid to the seller in 2002 and 2003 for the Environmental Water Account and Dry Year Water Purchase Programs operated by DWR ranged from $75 to $185 per acre-foot. The lower prices reflect a source in Northern California and the higher prices reflect the price to EWA of banked groundwater in Kern County with conveyance costs in years of 50 percent State Water Project allocations.

In addition to the direct costs of a water transfer to the receiving areas, indirect costs to third parties also can occur, and there could be impacts to other water users and the environment from water transfers. These concerns are discussed under the issues that follow.

Major Issues Facing Water Transfers

Maintaining Agricultural Productivity

Because most water transfers come from agriculture, it is important to include the protection of agricultural productivity and economic benefits in water transfer policies. A key challenge is to balance the ability of agriculture to provide water for transfers with protections in place so that transfers do not destabilize California's agricultural productivity and economy.

Balanced Approach to Regulating Transfers

There is a concern by some that State laws and oversight of water transfer are not adequate to protect the environment, third parties, public trust resources, and broader social interests that may be affected by water transfers. This is particularly the concern for water transfers involving pre-1914 water rights, which are not subject to regulation by SWRCB, long-term transfers, and transfers that involve pumping groundwater, crop idling, or crop shifting. Conversely, there is also concern that efforts to more heavily regulate water transfers may unnecessarily restrict many short-term, intra-regional transfers that have multiple benefits during temporary supply shortages and that have little likelihood of direct or indirect impacts. The key issue is how to balance these concerns to allow water transfers to continue as a viable water management strategy while having mechanisms to minimize effects on others.

Environmental Concerns

Environmental consequences of transfers could occur in three places: the area from which water is transferred, the area through which water is conveyed and the area to which water is transferred. Cumulative effects of short- and long-term transfers could have impacts on habitat, water quality, and wildlife caused by substituting groundwater for surface water, changing the location, timing, and quantity of surface diversions, reducing agricultural return flows to wildlife areas, or changing crop patterns through crop shifting or idling. For example, rice growing areas could have significant secondary benefits as wildlife habitat. Transfers that involve crop idling in these areas could either harm or benefit wildlife depending on implementation. Transfers that involve increased groundwater pumping also raise concerns over groundwater overdraft and the long term sustainability of groundwater resources. In addition, long term water transfers that induce new urban development in the receiving area may have environmental impacts.

Using Limited Duration Transfers for Long-Term Demands

There is a concern that transfers of limited duration are being used for long-term demands. For example, transfers under the Environmental Water Account, Central Valley Project Improvement Act, and related programs are designed to improve environmental conditions. Because these transfers rely in part on public funding that may not exist every year, they may not provide long term protection for the environment. There is also a concern that urban areas may use limited duration transfers to accommodate additional development with water supplies that are not sustainable. Finally, there is a concern that agricultural users may rely on limited duration transfers to supply crops, such as orchards, that cannot be easily scaled back during droughts.

Economic Concerns

Short term, out-of-county transfers created through extensive crop idling can reduce production and employment of both on farm and secondary economic sectors resulting in reduced tax revenues and increased costs for farmers who are not participating in the transfer. Extensive idling of crops that resulted in unemployment of low wage laborers could be considered unfair treatment under the State's environmental justice policies (see Government Code Section 65040.12). In addition reduced revenues could affect local governments disproportionately with potential impacts to spending on a wide range of services provided by local government. Long-term transfers could result in similar impacts even though the amount of fallowed land may be less. For long-term transfers, impacts to other elements of the local community (schools, businesses etc.) may be more widespread and severe. Transfers of surface water that are replaced by increasing groundwater pumping may drop groundwater levels and increase the pumping costs to other groundwater users, and may contribute to groundwater overdraft.

State law generally requires that water transfers not unreasonably affect the overall economy of the county from which the water is transferred (referred to as source areas). However, there is potential for some economic disruption to source areas depending on the source of transferred water, the amount of water transferred, and the duration of the transfer. While there is no evidence that recent water transfers have had long-term negative economic impacts to source areas, there is a concern that source areas could experience long-term economic impacts if transfers become more widespread. Water scarcity can also cause economic impacts, both where the shortage occurs and far beyond. Water transfers can help reduce water scarcity in areas receiving transfers thereby helping to avoid job losses and secondary economic impacts in these areas.

Quantifying Uncertainties and Effects on Others

Transfers, especially those where water is moved long distances, are limited by several factors including access to and physical capacity of conveyance systems, environmental and water quality regulations, evaporation, evapotranspiration, and seepage along the flow path, linkages between surface water and groundwater movement and use, and other factors that are difficult to quantify or anticipate. For example, those who traditionally relied on return flows from upstream areas as a source of supply are concerned about being affected by changes in timing and quantity of flows resulting from water transfers or water conservation measures. Quantifying the actual water savings from crop shifting and crop idling is particularly difficult because only the consumptive use by the crop is transferable in most cases. There is a risk that estimates of the water supply benefits from the transfer to the water system (estimates of "real water") will be inaccurate and that the transfers have unintended consequences to other water users, local economies, or the environment. A key challenge is to improve methods for quantifying these uncertainties and to include adequate monitoring and assurances when implementing water transfers. Monitoring is particularly critical for transfers that obtain water from crop idling, crop shifting, water use efficiency measures, or by increasing groundwater use. Information may be needed on historical and current land use and water use, groundwater levels, land subsidence, water quality, environmental conditions, and surface water flows.

Need for More Integrated Management of Water Resources

In California, authority is often separated among local, State and federal agencies for managing different aspects of groundwater and surface water resources. Several examples highlight this: 1) SWRCB has jurisdiction for appropriative water rights dating from 1914, but disputes over appropriative water rights dating before 1914 are settled by the court system; 2) Similarly, SWRCB has jurisdiction over groundwater quality, but disputes over groundwater use are settled by the court system ; 3) County groundwater ordinances and local agency groundwater management plans often only apply to a portion of the groundwater basin, and those with overlapping boundaries of responsibility do not necessarily have consistent management objectives. Failure to integrate water management across jurisdictions makes it difficult to develop transfers with multiple benefits, provide for sustainable use of resources, identify and protect or mitigate potential impacts to third parties, and ensure protection of legal rights of water users, the environment, and public trust resources.

Infrastructure and Operational Limits

The ability to optimize the benefits of water transfers depends on access to and the physical capacity of existing conveyance and storage facilities. For example, when export facilities in the Delta are already pumping at full capacity, transferable water cannot be moved. This occurred in 2003 when the Metropolitan Water District of Southern California (MWDSC) negotiated water transfers with growers in the Sacramento Valley but was unable to move water through the Delta where the conveyance system was flowing full, or to store the water in Lake Oroville, which filled with late spring rain. The ability to convey water is also an important aspect of water transfers between the Imperial Irrigation District and the San Diego County Water Authority, which requires access to the Colorado River Aqueduct owned and operated by MWDSC.

Recommendations for Water Transfers

1. Since local government and water agencies have the lead role in developing and implementing water transfers they should:
   a. Develop groundwater management plans to guide implementation of water transfers that increase ground water use or that could impact groundwater quality.
   b. Implement monitoring programs that evaluate potential specific and cumulative impacts from transfers, provide assurances that unavoidable impacts are mitigated reasonably, and demonstrate that transfers comply with existing law.
   c. Evaluate and implement regional water management strategies to improve regional water supplies to meet municipal, agricultural, and environmental water demands and minimize the need of importing water from other hydrologic regions.
   d. Provide for community participation when identifying and responding to conflicts caused by transfers they are a party to.
2. State and federal agencies, in addition to implementing State and federal law, should assist with resolving potential conflicts over water transfers when local government and water agencies are unable to do so and when there are overriding State or federal concerns.
3. State and federal agencies, working through the CALFED Water Transfers Program, continue to gain consensus on how best to implement water transfers. The fol lowing actions are on-going and should be continued and improved:
   a. Preparing programmatic and site specific CEQA/NEPA documents to assess cumulative effects of inter-regional transfers anticipated to occur under the Environmental Water Account and Sacramento Valley Water Management Agreement.
   b. The SWRCB, DWR, and DFG must consider whether the transfer is likely to harm public trust resources, such as fish and wildlife, and must protect trust resources whenever feasible. The SWRCB and DWR, after considering all available information, including CEQA documents or other environmental documents and the input of DFG, may put conditions on transfer to protect trust resources. If the SWRCB or DWR find that proposed transfer will cause undue harm to trust resources, they may (1) add terms to avoid the harm (2) the SWRCB may deny the petition or (3) DWR may deny the use of its facilities. In many cases, transfers will not result in harm to public trust resources.
   c. Under Section 1802 of the Fish and Game Code, DFG must exercise its responsibilities as trustee for the resources of the State with jurisdiction over the conservation, protection, and management of fish, wildlife, native plants, and habitat necessary for biologically sustainable populations of those species.
   d. Improving conditions in the Delta and identifying and reducing statewide conveyance limitations.
   e. Streamlining the approval process of State and federal agencies for water transfers while protecting water rights, the environment, and local economic interests.
   f. Working with agencies proposing water transfers that move water through the Delta to monitor and evaluate short-term, long-term, and cumulative effects that could impact the condition of the Bay-Delta ecosystem.
   g. Refining current methods on how to identify and quantify water savings for transfers using crop idling, crop shifting, and water use efficiency measures. This should be accomplished through a collaborative process that considers methods developed by others.

h. Developing, with interested parties, acceptable ways to identify, lessen, and distribute economic impacts from transfers that use crop idling and crop shifting.
i. Providing financial assistance for local and regional groundwater management activities that promote sustainable and coordinated use of surface water and groundwater.
j. Seeking consensus among interested parties about the role of water transfers as a water management strategy while identifying and preventing or mitigating potential impacts to other water users, third parties, the environment, and public trust resources.
k. Providing technical assistance and guidelines for assessing cumulative impacts of transfers, including concurrent or consecutive one-year transfers within the same region, on other water users, local economies, and the environment.

4. State and federal agencies, working through the CALFED Water Transfers Program, should implement the following actions to improve management of water transfers:
   a. Improve coordination and cooperation among local, State, and federal agencies with different responsibilities for surface water and groundwater management to facilitate sustainable transfers with multiple benefits, allow efficient use of agency resources, and promote easy access to information by the public.
   b. Develop water transfer policies that balance the ability of agriculture to provide water for transfers on a periodic basis to help with temporary water scarcity with limits so that transfers do not destabilize agricultural productivity and economic benefits.
   c. Facilitate cooperation among agencies proposing water transfers and regulatory agencies to obtain multiple benefits from proposals. For example, transfers intended for urban or agricultural use may also be scheduled to enhance flows for aquatic species in areas between the seller and buyer.
   d. Implement water transfers, when serving as a purchaser, in cooperation with local partners, consistent with State water and environmental laws, and at a fair price.

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Volume 2

Chapter 24 Water-Dependent Recreation

Water-dependent recreation as a strategy helps water managers find opportunities to enhance recreation on and around the water. (DWR photo)

Chapter 24 *Water-Dependent Recreation*

Water-dependent recreation includes a wide variety of outdoor activities that can be divided into two categories. The first category includes fishing, boating, swimming and rafting, which occur on lakes, reservoirs, and rivers. The second category includes recreation that is enhanced by water features but does not require actual use of the water, such as wildlife viewing, picnicking, camping and hiking.

Water-dependent recreation is included among the water management strategies because recreation is an important consideration for water managers. Water management, and water infrastructure, can have significant effects on recreation. By considering recreation during the planning process, water managers can take advantage of opportunities to enhance recreation, and can guard against actions that would limit recreation.

The Davis-Dolwig Act was passed by the California Legislature in 1961. This act established State policy regarding recreation and fish and wildlife enhancement at State-built water facilities, and specified the responsibilities of State agencies under the act. Compliance with the provisions of this act is an important consideration for state water managers when new facilities are built.

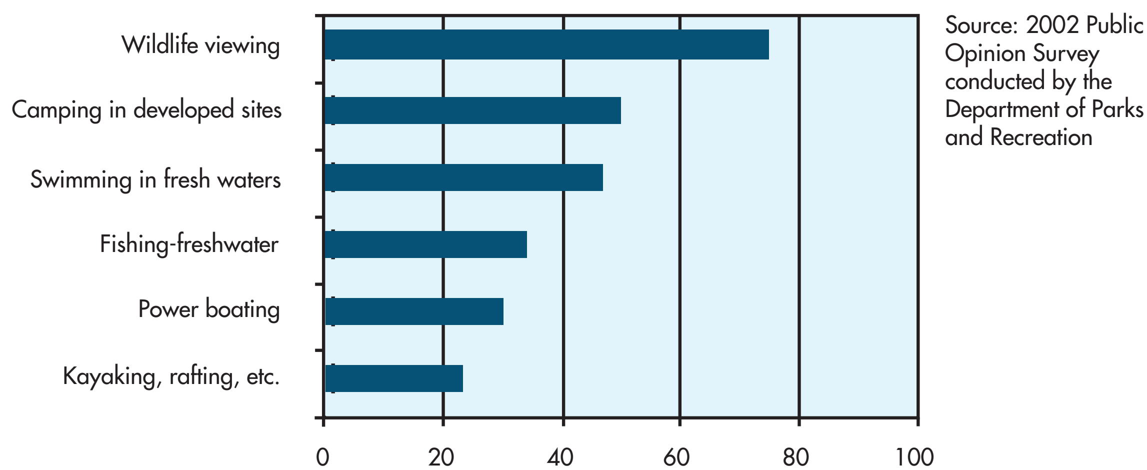
The management of lands and water resources by the State, including those associated with State water projects, invokes an implied principle of trust responsibility. State agencies managing lands and water resources are required to uphold public trust in the planning, management, use and protection of resource values. As trustee to public resources, the State must consider the benefit and use of land and water resources for recreational opportunities. As discussed in Chapter 2 of Volume 1, the Public Trust Doctrine recognizes recreation as one of the public trust uses that State agencies must take into account when managing tidelands and navigable waters and their tributaries.

Current Participation in Water-Dependent Recreation in California

California's temperate climate provides a long season for outdoor recreation, and water is a magnet for outdoor recreation. Figure 24-1 shows the percentage of Californians participating in various water activities. In 2002, about 150 million adult participation-days were spent in recreation activities directly dependent on water. Many more visitor-days were spent in nature-based activities such as wildlife viewing, 55 million adult participation-days, and hiking, 36 million adult participation-days. In addition, water recreation is a large draw to tourists, helping to attract 28 million visitors in 2001. The 2002 *Public Opinion and Attitudes on Outdoor Recreation in California* clearly shows strong support for water-related activities.

- Slightly more than 80 percent of the respondents indicated that more outdoor recreation areas, such as picnic and camping sites, are needed at lakes and reservoirs.
- When asked to assign a priority score from 1 (extremely low priority) to 10 (extremely high priority) for providing more public-use opportunities at lakes and reservoirs, nearly 85 percent recorded a 5 or better and 16.7 percent gave it a 10, an extremely high priority.
- Nearly 79 percent of the respondents indicated that the availability of lakes, reservoirs, rivers, and wetlands was either very important or somewhat important factor in their overall enjoyment of their favorite outdoor recreation.

Figure 24-1 Percentage of Californians participating in these water-dependent activities



A significant number of Californians participate in a number of water-dependent recreational activities, which can be divided into two categories: (1) fishing, boating, swimming and rafting and (2) wildlife viewing, picnicking, camping and hiking.

Benefits of Water-Dependent Recreation

Water-dependent recreation provides a wide range of health, social and economic benefits to California residents and visitors, while improving the quality of life. It encourages physical activity, such as swimming and paddling, as well as walking and bicycling along attractive waterside trails.

Water-dependent recreation influences tourism, business and residential choices. It increases expenditures in the community for travel, food and accommodations. In 2001, California had 28 million out-of-state tourists spending an average of $76 a day and staying an average of four days. In addition, 196 million resident tourists spent an average of $70 a day. Sales of sportfishing licenses and stamps generated more than $49 million in annual revenue for the Department of Fish and Game in 2001 and 2002. Water-dependent recreation prompts long-term investments while creating jobs in concessions, hotels, restaurants, and retail stores. Figure 24-2 shows economic information for freshwater fishing, only a portion of all water-dependent recreation; total economic output from freshwater fishing exceeded $3 billion.

Potential Costs

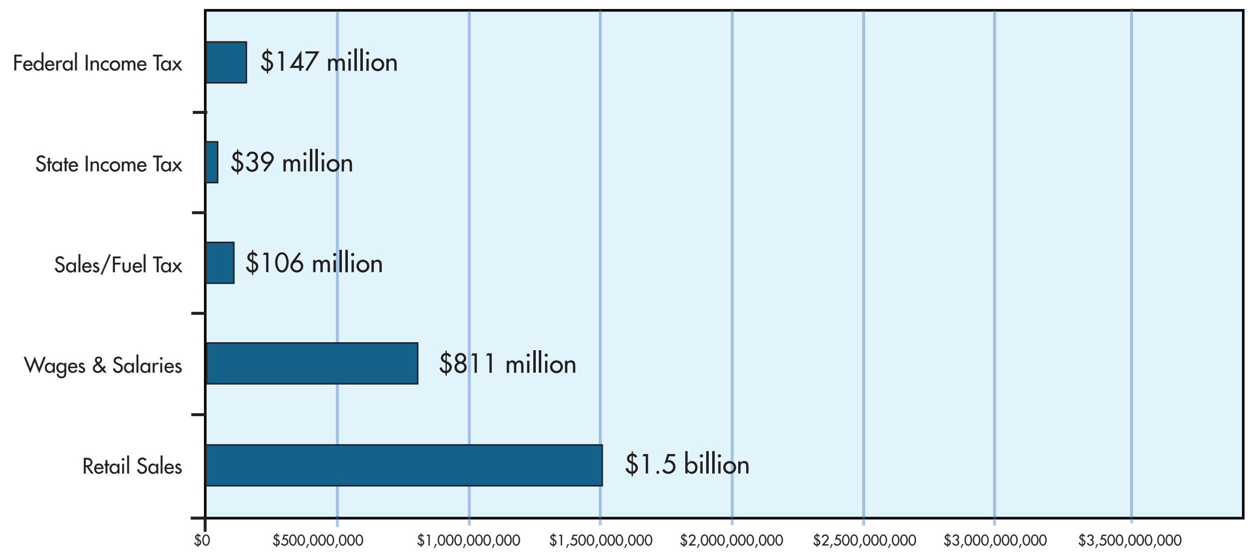
Initial development costs of recreation facilities can vary with the size of the project. Generally 3 percent to 6 percent of total project costs are allocated for development of permanent recreation facilities. For example, the capital cost of recreation sites on the State Water Project is about 3 percent of all capital expenditures for the SWP. Annual maintenance costs are just over 3 percent of the initial development costs of recreation facilities.

Major Issues Facing Development of More Water-Dependent Recreation

Funding

Funding concerns usually transcend all other issues affecting outdoor recreation, including water-dependent recreation. These funding issues fall into two categories: planning and development of new recreational sites associated with water projects, and operation and maintenance of recreation sites once they are in place. When new dams, reservoirs or canals are being built, there may not be enough money to fully incorporate recreation. One reason for this is that the beneficiaries of recreation may be different from the other beneficiaries of the water project, requiring complex funding mechanisms to fully support recreation planning. This is a significant issue in State Water Project planning: The Davis-Dolwig Act specifies that water users shall not be charged for the cost of recreation facilities, but other funding mechanisms have not always been made available. Maintenance of recreation facilities may be more susceptible to funding cuts during poor economic condi-

Figure 24-2 Economic output to California from freshwater fishing by licensed anglers (2.2 million) in 2001



Water-dependent recreation influences tourism, business, and residential choices. It increases expenditures in the community for travel, food, and accommodations. Total economic output from freshwater fishing exceeded $3 billion in 2001, which is only a portion of all water-dependent recreation.

tions than for other resources thought to be more essential. Without reliable funding, it is difficult for recreation providers to deliver quality, consistent and relevant facilities and services to meet growing demand. Many park and recreation providers have taken steps to reduce programs and operating costs to become more efficient on leaner budgets by raising fees and charges, reducing or eliminating services, delaying equipment purchases, and deferring land acquisition, facility developments, rehabilitation and renovation of aging infrastructure. Inconsistent funding also makes it difficult to plan for services and reduces the willingness of many service providers to offer new programs or to take risks.

Online Sources of Information

- *Department of Fish and Game, License and Revenue Branch, www.dfg.ca.gov*
- *American Sportfishing Association, www.asafishing.org*
- *California Department of Tourism, www.gocalif.ca.gov*

Impacts to Natural Resources

Natural resource values often define the character and aesthetic appeal of a water-dependent recreation, making it desirable and interesting to visitors. Overuse, misuse and poorly planned uses of any recreation resource can degrade natural resource values and recreational experiences. Water management can affect the amount or timing of stream flow. This may have a good or bad effect on recreation. Water managers should consider the effects of their actions on all resource values, including recreation as well as ecosystem health. Increasing numbers of visitors pursuing outdoor recreation threatens the proper functioning of ecosystems, disrupts and displaces wildlife and degrades the natural, environmental and aesthetic quality of an area and ultimately the very recreational experience being sought. In addition, visitors unfamiliar with ecological processes or environmental ethics are often unaware of the consequences of their actions.

Water Quality

Water quality can affect and be affected by water-dependent recreation. Poor water quality can have a negative impact on water-dependent recreation. A source of contamination is untreated sewage escaping from treatment facilities or broken sewer lines that have led to the highly publicized closure of public beaches. Another source is fertilizers and chemicals from agricultural runoff that also contribute to the problem. Contaminated lakes, rivers and streams not only present health risks to those participating in water-contact recreation, but they can significantly diminish the recreation experience. In reverse, the negative effects water-dependent recreation can have on water quality are also of concern. Human-source contamination, such as body contact, untreated sewage, and petroleum products discharged from houseboats and other pleasure craft can be a significant problem to water meant for drinking.

Coordination

Funding and impacts to natural resources are exacerbated by the lack of coordination between those who manage water resources and those who provide recreational services. All too often, agencies are limited in scope and effectiveness in recognizing and mitigating trends affecting resource conditions, particularly outside their immediate jurisdiction. While partnerships and cooperation between agencies, organizations and individuals have grown, efforts at the watershed or landscape level are often fragmented, and opportunities are missed to achieve broader goals, placing both resources and the public at risk.

Recommendations to Help Provide Adequate Water-Dependent Recreation

1. In developing water-dependent recreation opportunities, jurisdictions should consider public needs as identified in the California Outdoor Recreation Plan.
2. Use existing data and new surveys to determine recreational needs that might be met by incorporating recreation more fully into new state and regional water project planning.
3. Develop closer working relationships among DWR, DFG, and DPR so that recreation planning is incorporated appropriately into CALFED program planning.
4. Conduct, and periodically re-examine, scientifically valid studies of the carrying capacity of proposed and existing sites for water-dependent recreation to help prevent degradation of water quality and wildlife habitat. Use data collected by other agencies, such as the U.S. Bureau of Reclamation, U.S. Army Corps of Engineers and for the Federal Energy Regulatory Commission, such as the results of FERC Relicensing studies.
5. Collect data on visitation rates vs. reservoir water levels and downstream flow rates, and use this data to help optimize the timing of water that is released or held for recreation.
6. Develop partnerships with universities to coordinate the monitoring of public recreation use, equipment and emerging outdoor and water-dependent recreation trends. Create partnerships with education providers to educate youth about preserving and protecting natural resources.
7. Promote and establish effective partnerships between federal agencies, state and local governments, and the private sector for operation, maintenance and law enforcement of water recreation sites.
8. Coordinate with the Department of Fish and Game in exploring the use of funding from the Bay-Delta Sport Fishing Enhancement Stamp to integrate new and improved public angling opportunities.

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California Department of Parks and Recreation, "California Outdoor Recreation Plan 2002," www.parks.ca.gov/planning

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State Board of Forestry, California Department of Forestry and Fire Protection, "The California Fire Plan," www.fire.ca.gov

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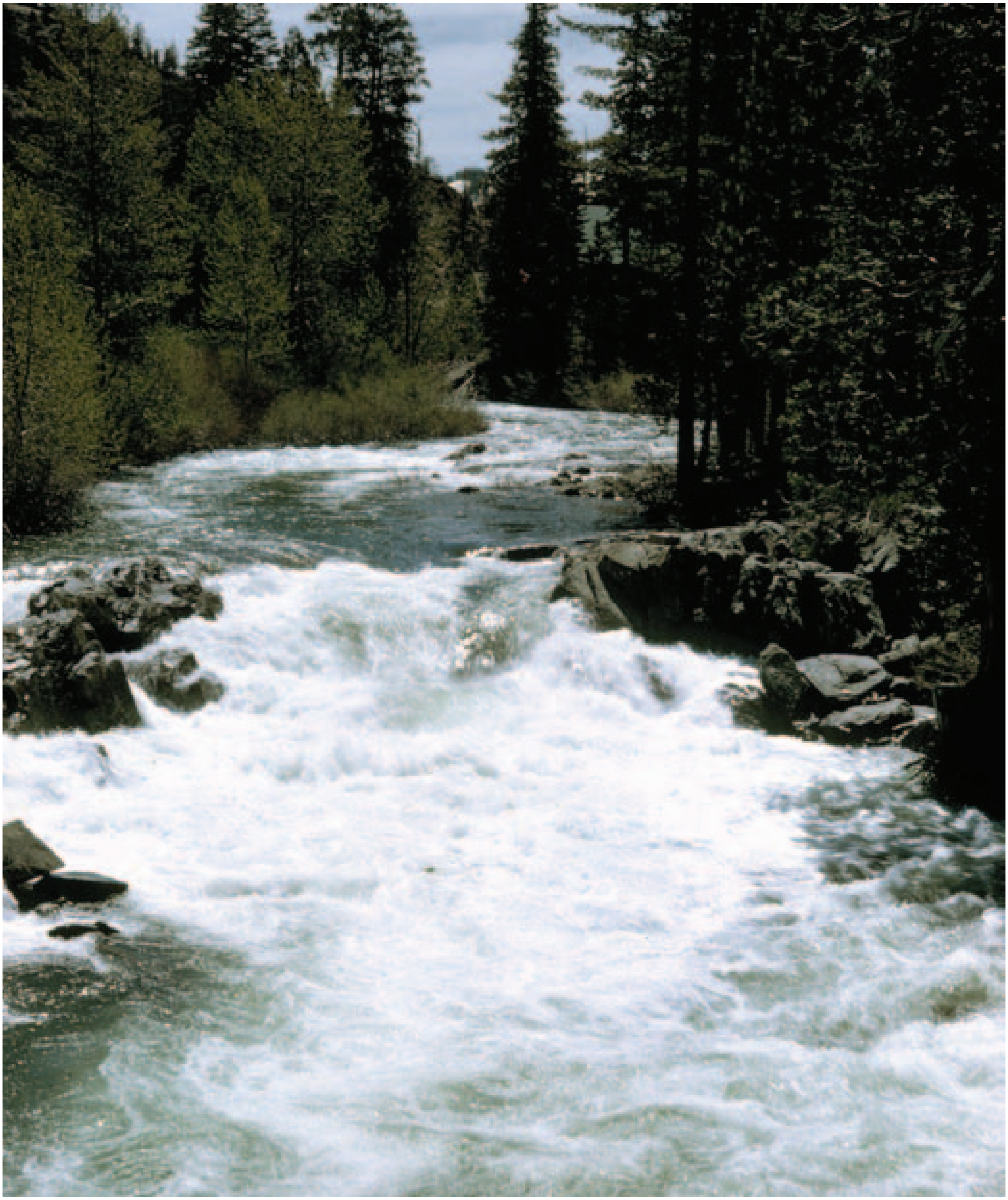
Chapter 25 Watershed Management



Watershed management integrates human needs and ecological condition to allow the watershed to sustain ecological integrity over time while providing sustainable community needs. (DWR photo)

Chapter 25 *Watershed Management*

Watershed management is the process of evaluating, planning, managing, restoring, and organizing land and other resource use within an area of land that has a single common drainage point. Watershed management tries to provide sustainable human benefits, while maintaining a sustainable ecosystem. Watershed management assumes that a prerequisite for any project is the sustained ability for the watershed to maintain the functions and processes that support the native ecology of the watershed. This does not imply that a goal is to return the watershed to an undisturbed condition. Instead it implies an integration of human needs and ecological condition that allows the watershed to sustain ecological integrity over time while providing for sustainable community needs. It is recognized that watersheds are dynamic and the precise makeup of plants, animals, and other characteristics will change over time. Watershed management seeks to balance changes in community needs with these evolving ecological conditions.

Watersheds offer a convenient scale for considering how factors can degrade or enhance resource conditions (See Box 25-1). Watersheds collect all of California's precipitation, rain, snow, and fog; filter or treat much of it; store more water than all of the state's reservoirs combined; and release water to rivers and groundwater at rates that vary with watersheds. Managing our watersheds can be thought of as the necessary maintenance of our natural infrastructure.

The natural processes that make watersheds valuable to the state are susceptible to damage and degradation. That damage threatens to significantly impact and reduce the ability of those watersheds to function and provide those benefits that the state depends upon. This is evident through reductions in water infiltration, degradation of water quality, increased maintenance costs from erosion related impacts, changes in runoff patterns and timing, decreased ability of mountain meadows to capture and hold snowmelt for later natural accretion into streams, and decreased populations of native flora and fauna. These factors threaten the state's economy that is directly, and indirectly, dependent on the condition and trend of its watersheds.

Underpinning watershed management is the need to understand ecological processes important to the local watershed. One approach to understanding these processes is to describe various ecological cycles and watershed traits, such as the hydrologic cycle, nutrient cycling, energy flow and transfers, soil and geologic characteristics, the role of fire, and animal migration and habitat utilization (See Box 25-2). Understanding these watershed processes allows for adaptively managing the watershed. In some cases the description of these processes will highlight that some infrastructure, programs, or projects are not sensitive to watershed processes. In these cases reoperation or redesign the infrastructure, programs, or projects may greatly improve their compatibility with the watershed processes.

Box 25-1 What is a Watershed?

In its simplest context a watershed is an area of land with a single common drainage point. In the context emerging for planning purposes in California, a watershed includes living (including the people who live and work in the watershed) and non-living elements within a defined geographical area that is generally characterized by the flow of water. The flow of water defining a watershed includes both surface water and groundwater as it moves through natural and manmade features, from higher elevations to lower elevations. Throughout the state we have engineered the flow of water such that defining watershed boundaries is often prefaced on hydrologic features but adjusted to accommodate water conveyance systems. In some cases planning watershed boundaries may be influenced by administrative boundaries as well, such as city limits.

Watershed Management in California

Groups pursuing watershed management are now operating in all regions of California. It is estimated that several hundred watershed stewardship groups are now active in the state. A recent request of watershed management grant proposals produced more than 330 applications from all parts of the state. Proposals included both local and regional projects. Local projects addressed support for local stewardship groups, watershed assessment, and planning and project implementation. Regional proposals centered on creating and coordinating networks for local watershed groups. From strictly private land holdings to consortia of public and private interests, people are focusing on the watershed scale as a way to create understandable and meaningful resource management efforts that provide multiple benefits and are designed to achieve sustainable ecosystems (See Box 25-3).

Box 25-2 Issues Facing California Watersheds That Affect Water

Land uses alter hydrologic cycles – The hydrologic cycle includes snow or rain, the flow of water over and beneath the land, and the evaporation of water into the atmosphere. How the land is managed can reduce rainwater infiltration and the timing, and in some case, the volume of stormwater runoff. Storms, especially in urban areas, but also in some rural areas are now marked by high intensity runoff over short periods. This creates greater flood risk and reduces the ability to capture water for needs during dry times. From an ecological perspective, this compression of runoff events robs the streams and landscape of groundwater. This leads to dry land, a shift in vegetation types, lower and warmer streams, deterioration of stream channels, all of which lead to shifts in the plants and animals that can be supported. In some cases the diversion of water from streams in the watershed to other regions outside the watershed or the application of water imported from outside the watershed has changed ecological functions or altered the flow of water through the watershed.

Human activities alter nutrient cycles – Another important natural cycle is the nutrient cycle. As watersheds are developed we tend to increase the amount of water soluble nutrients, often concentrating them in fertilizers or biosolids. These concentrated forms of nutrients can trigger dramatic changes in water bodies, vegetation, and animal communities. Many native plants evolved under fairly low nutrient conditions. Increasing the available nutrients often allows invasive plants to overrun the native vegetation. This can reduce the infiltration capacity of the land and diminish the habitat quality. We often export nutrients from the location that they are generated. In some cases this is through the pollution of water which carries the nutrients to a point where they can support algae or other plant growth that impairs the water. In other cases this is through the transport of waste materials or the application of fertilizers. In any event, the result is an increase in nutrient loads that often diminish the ecological quality in water bodies.

Disrupting habitats and migration corridors – Life cycles and migration patterns of animals is another set of important cycles to consider. Many projects built in the past prior to environmental laws such as CEQA and NEPA have disrupted migration corridors or destroyed or impoverished habitat that is critical for certain life stages of animals. Coastal wetlands that support breeding, nursery and rearing habitat for many ocean species have been particularly hard hit. Dams have blocked access to spawning and rearing habitats for anadromous fish. Riparian forests that support migration of South American birds, and inland wetlands that support the Pacific Flyway species have all been severally impacted.

Fire and water – The management of our forest and brush lands over the past few generations has created a risk of very large, very hot fires that do much more damage to watersheds than fires of historical intensities. The result is that watersheds are not capable of rapidly repairing the damage from these fires. These fires create long periods of erosion and diminish the plant communities that cover the land. They displace animals and limit the subsequent human use of the lands. This results in more water quality problems, more runoff and less infiltration, increased operations and maintenance costs for our reservoirs and canal systems, unstable lands, and large economic losses.

Current watershed management efforts blend community goals and management consistent with the environmental conditions of the watershed. The emphasis on community interests has introduced new methods for managing public discourse within stewardship groups and for collectively identifying principles and projects that are important to the local community. Issues of environmental justice have emerged and been blended into the more traditional project management approaches. Watershed stewardship groups serve as forums for coalescing the needs and capabilities of public and private sector interests, and people who work at the local, regional, state, national, and even international levels.

In addition to the local and regional efforts, a number of statewide initiatives have recently been undertaken to improve our overall ability to practice watershed management. While past bond acts provided specific funding for watershed projects (Propositions 204 and Proposition 13), recent bond acts stress the need for integrated plans and contain incentives to design projects consistent with these plans. This demonstrates just one manner in which watershed planning has evolved in the past decade in California. The bond acts and subsequent legislation associated with Propositions 40 and 50 have established statewide programs for Integrated Watershed Management and Integrated Regional Water Management that support managing resources on a watershed scale and conducting the public outreach, education, and project management required in watershed management efforts. A memorandum of understanding (MOU) exists that directs agencies within the Resources Agency and CalEPA to coordinate their efforts in support of watershed management. One focus of the MOU is to ensure that various state grant programs work in concert to address the most important aspects of watershed management in key watersheds throughout the state. Another focus is to facilitate coordinated work of various state programs involved in watershed management. An 18-month action plan will guide specific project work identified to address these issues.

Recent legislation established the California Bay Delta Authority and, in part, assigned it the responsibility to maintain a watershed program. The initial goals of this program are to

Box 25-3 Some Activities That Might Improve Watershed Management

1. Conduct normal business in a manner consistent with watershed dynamics and characteristics.
2. Design projects with ecological processes in mind and with a goal of making the projects as representative of the local ecology as possible.
3. Establish adaptive management programs that regularly assess the performance and condition of projects to deter mine if they are satisfying ecological and community needs. Adjust the operations or design the projects as needed.
4. Place projects in the watershed in a way that allows them to reinforce each other and build on the impacts collectively to support the local ecological cycles.
5. Increase the ability for precipitation to infiltrate into the ground, reduce surface runoff to a point where it reflects a natural pattern of runoff.
6. Restore and preserve stream channel morphology to allow access of flood waters to the floodplain and to provide for stable banks and channel form.
7. Maintain and create habitat around stream and river corridors that is compatible with stream and river functions. Provide as much upslope compatibility with these corridors as possible.
8. Rely on native plant communities where feasible in landscaping, agriculture, forestry, and restoration work.
9. Incorporate nutrient cycles that rely on the local watershed to supply and receive nutrients for important processes in the watershed.
10. Preserve features that support migration corridors or critical life stage habitats.
11. Sponsor and participate in watershed stewardship groups.

Note: All activities may not be applicable to all watersheds.

build local capacity to engage in watershed management, to promote the development of watershed assessments and plans, and to support specific projects designed to improve local management of watershed resources. The goals for the CALFED Watershed Program are to provide assistance, both financial and technical, for watershed activities that help achieve the mission and objectives of the CALFED, and to promote collaboration and integration among existing and future local watershed programs. The CALFED Watershed Program, with assistance from various State agencies, manages a grant program to achieve these goals.

The combination of a rapidly increasing number of local watershed management efforts and improved grant funding has broadened the interest in watershed management so that local public agencies that once relied on narrow program funding for support are engaging in watershed management to address their needs.

Benefits of Watershed Management

Improve Water Supply Reliability and Management Flexibility

Watershed scale assessments, restorations, and projects have illustrated the potential to improve the ability to capture, store, and use water. For example, in the Feather River Watershed, meadow restoration has improved the ability of the watershed to capture snowmelt and spring runoff, which in turn has lowered flood potentials and increased summer base flows in streams. This provides improved ability to capture water in summer for export in the State Water Project. It also potentially reduces operations and maintenance costs of projects in the watershed and alleviates flood damage. These improvements are consistent with the natural hydrology of the basin and serve to restore many ecological functions associated meadows and streams.

Preserving Ecological Functions and Processes

Watershed management helps preserve ecological functions and processes by helping us consider natural cycles (hydrologic, nutrient, and life cycles) when designing projects. For example elevated stream temperatures are often identified as a problem. Promoting groundwater accretion to streams and improving riparian cover often cools stream temperatures. Designing projects to allow more water to soak into the ground, less water to sheet off as runoff, protecting the soil surface from erosion by planting native plants, and stabilizing stream channels with vegetated buffers brings the stream more in line with the natural watershed cycles and sustains important ecological processes.

Reducing Flooding Potential

Watershed management helps reduce flooding along streams draining the watershed. Preserving a more natural vegetated channel configuration and overflow areas helps slow and lower peak flows.

Improving Water Quality

Watershed management helps improve water quality by maintaining natural vegetated stream buffers that filter pollutants and nutrients.

Connecting to Other Things in the Watershed

Identifying important aspects of the watershed condition and trend can help guide activities to achieve a sustainable watershed that is connected with the working ecology. Watershed management helps identify how a new project has influences beyond the immediate project area and highlights opportunities for further watershed enhancements. In addition, it allows for easier identification of risks to sustaining the essential characteristics of the watershed. Understanding these influences provides opportunities to conduct business in a manner that is supportive of watershed dynamics.

Enduring Value

Watershed management provides the ability to generate enduring value from the integration of ecology and community interests. The melding of interests reduces or eliminates competition for resources, provides satisfying outcomes to many people, and yields cost effective solutions. Participation on a watershed management or stewardship group can give people a safe and open forum to express their ideas. Projects that are designed with an ecological scale in mind have a lower risk of being undermined by natural events than projects designed only looking at the site scale. Projects incorporating ecological conditions also preserve and enhance ecological conditions for future generations thereby contributing to fulfilling Public Trust responsibilities (see Volume 1, Chapters 2 and 3).

Costs Associated with Watershed Management

Costs associated with watershed management depend on site specific conditions such as the size of the watershed and actions to be implemented. In some cases, the actions will include physical projects to alter watershed conditions and in other cases the actions will be limited to programs that simply influence watershed use.

Table 25-1 Preliminary estimates of watershed management costs

Period (years)	Assessment-Planning [1] ($ million)	Public Process [2] ($ million)	Projects [3] ($ million)	Total for period
2004-2009	$10-37.5	$8-16	$14-80	$160 - 667
2010-2015	$10-30	$8-16	$14-88	$160 - 804
2016-2030	$10-25	$8-16	$14-100	$160 - 2,115
Total				$480 - 3,586

[1] CALFED service estimated as 40% of statewide need. Therefore, statewide Assessment and Planning = 2.5 x CALFED values from Draft CALFED Finance Plan.

[2] The service area for Public Process estimated as 25% of statewide need. Therefore, statewide Public Process = 4 x CALFED values.

[3] For Projects, CALFED service area is estimated to be 25% of the statewide need. Therefore, statewide Public Process = 4 x CALFED values.

Currently, costs are incurred for measuring various features in the environment, planning projects, and building the projects. Incorporating ecological functions into projects does not necessarily add costs. For example, some nurseries in Southern California have found that by growing plants in the peripheral drainage ditches of their properties they are able to reduce nutrient discharges and wastewater while growing a saleable crop. In agricultural settings tailwater ponds and vegetated canal systems have replaced disking and spraying of field edges and canal banks. Providing stream systems access to their floodplains has reduced the potential damage from levee failures and lowered maintenance costs.

Some activities that may result in new costs (rather than simply redirecting existing expenditures) include watershed monitoring and assessment, support for watershed coordinators, increased restoration work, preservation of certain land use capabilities through easements or other forms of fee-titled adjustments, and extended periods of time in planning and design to accommodate watershed ecology. Actual costs for these activities are difficult to estimate and may largely be offset by savings in other aspects of watershed management, such as water supply reliability, flood damage reduction, reductions in threatened and endangered species listings.

DWR estimates about $0.5 billion to $3.6 billion could be spent on watershed management in California to year 2030. The estimates are based on scaling CALFED watershed management estimates up for statewide coverage. Table 25-1 shows these estimates by time period.

Major Issues Facing Additional Implementation of Watershed Management

Lack of Appreciation for the Role of Watersheds

In general the role of watersheds in sustaining our economies, businesses and communities is not fully appreciated. Providing for a greater understanding of watershed dynamics and how our communities and economies rely on their local watersheds will require working within schools, encouraging the business community to become involved in watershed management, and providing opportunities and incentives to the larger community to be involved in watershed management.

Fairness, Inclusion and Decision Making

Because many watershed projects are collaborative, projects often require coalitions to successfully implement them. However, the governance of these groups is not standard. They range from ad-hoc groups, to formal delegations of authority. Discussions often take significant time. All participants do not have the same ability to stay involved so issues of fairness and inclusiveness can arise.

Science and Understanding

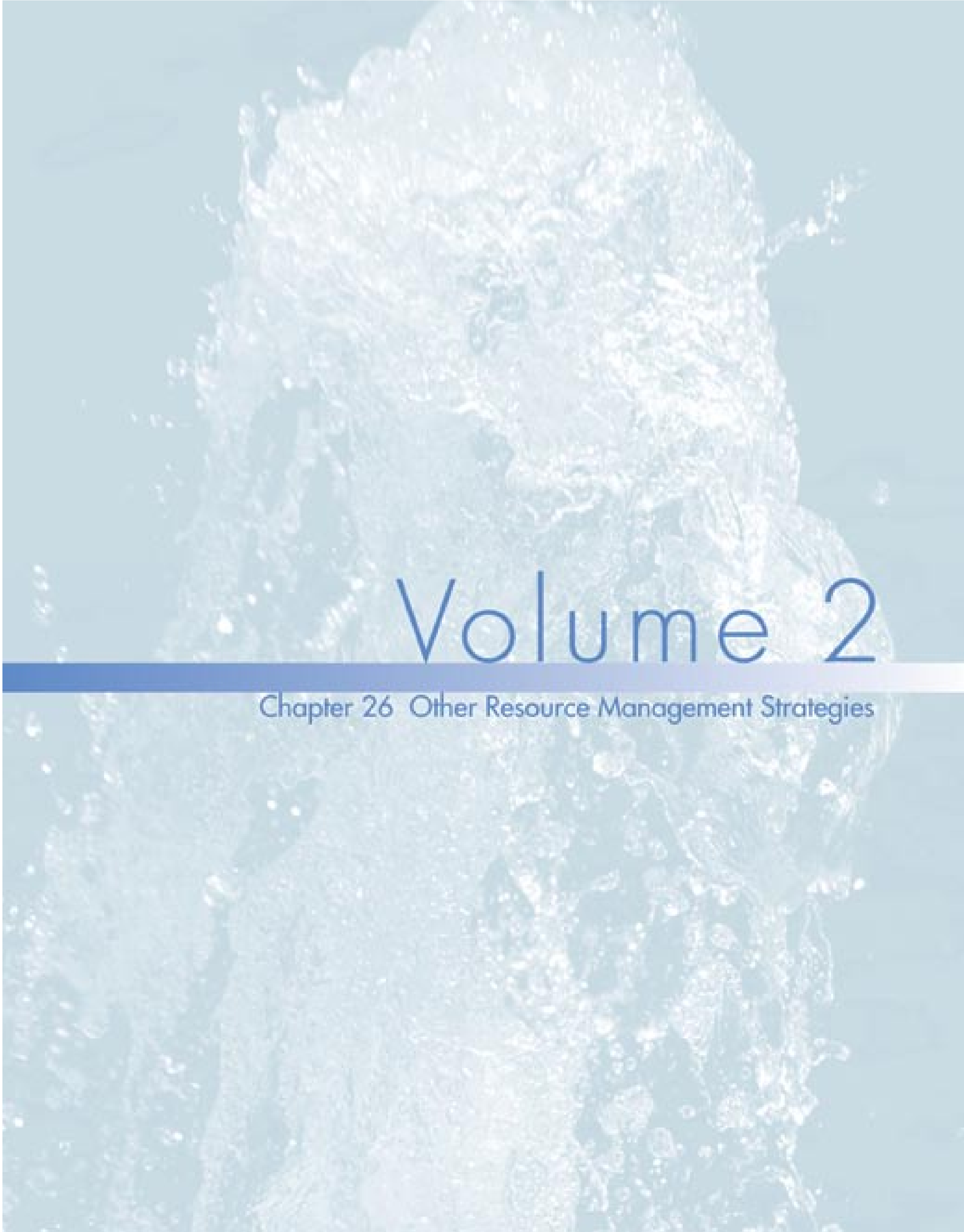
There is not a readily available source for finding key ecological information that can be incorporated into projects. Scientific assessments seek to provide a good technical description of watershed conditions, but cannot be definitive. State agencies can help in describing important ecological processes and functions throughout the state. As watershed assessment matures, a better understanding will likely emerge and more localized information will become available.

Adaptive Management

Adaptive management requires the regular measurement of various watershed projects and characteristics. It also requires assessing these measurements and designing and implementing responses to findings that suggest the watershed is not being managed well. In relatively few cases have watershed stewards established and maintained the needed monitoring and assessment activities. Efforts to respond to periodic assessments often are not pursued from a watershed scale, instead being limited to project specific issues.

Recommendations to Help Promote Additional Watershed Management

1. State, federal, local, public and private interests should develop new means to collectively reinvest in sustaining watershed ecological and social health. Particular attention should be paid to developing means for urban areas to reinvest in sustaining the quality of rural watersheds that provide water supplies for the urban areas.
2. Watershed management assessments and plans must include quantitative efforts to improve water supply flexibility and the timing and amount of water available for diversion without significantly impacting watershed condition or trend.
3. State grant-distribution should be based on meeting specific criteria that support watershed assessments, planning, public involvement, and integrated project design and operations that result in multiple benefits.
4. Education efforts to inform the general public and specific constituencies about the role watersheds play in sustaining their communities should be undertaken at all levels of watershed management. Specific efforts to link to schools including K-12, community colleges, and universities should be undertaken by State grants and agency programs working on watershed scales.
5. State agencies should pursue the goals and initiatives in the California Agency Watershed Management Strategic Plan (draft August 18, 2003).
6. State and local agencies should improve and expand their expertise in broad-based public decision making processes and participate in watershed stewardship groups. Attention should be paid to improving the use of stewardship group processes to help in achieving agency program responsibilities.
7. Watershed management efforts should design and implement, supported with State, federal, and local resources, adaptive management programs that include monitoring, assessment, and processes for defining project redesign and re-operations that bring management efforts more in line with local ecological functions. Adaptive management support should include funding for citizen monitoring of watershed conditions including water quality monitoring.
8. Fish and wildlife resource managers should be encouraged to develop management plans on an ecosystem or watershed basis as opposed to what is often species-specific.
9. Environmental, social, and economic benefits of public and private managed wetlands should be integrated into watershed management efforts including planning, education, water quality, flood control, and groundwater recharge.



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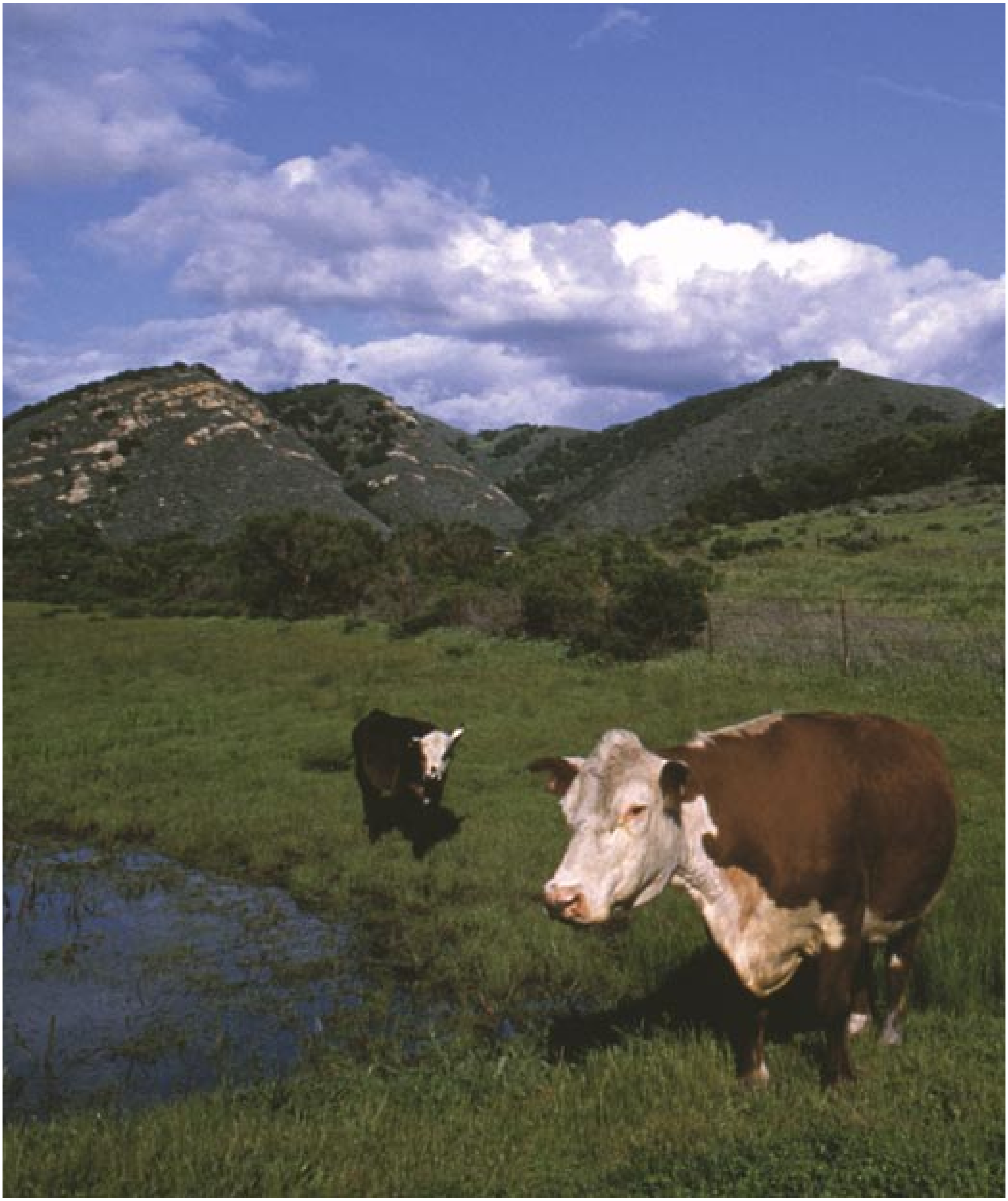
Chapter 26 Other Resource Management Strategies



Some resource management strategies are limited in their capacity to strategically address long-term regional water planning needs, although they may meet one or more water management objectives. Dry-land farming relies on rainfall alone to sustain the land's agricultural use. (DWR photo)

Chapter 26 *Other Resource Management Strategies*

This narrative highlights a variety of water management strategies that can potentially generate benefits that meet one or more water management objectives, such as water supply augmentation or water quality enhancements. However, these management strategies are currently limited in their capacity to strategically address long-term regional water planning needs. In some cases, such as Dewvaporation, the strategy involves emerging technologies that will require more research and development. In other cases, such as Crop Idling and Irrigated Land Retirement, they involve voluntary and often temporary tradeoffs from one sector of use to another (i.e., agricultural to urban) that will likely be unpredictable and limited in scope over the time horizon of this California Water Plan Update. Finally, implementation of strategies such as Rainfed Agriculture will have limited applicability in California due to the variability and uncertainty of precipitation patterns within the state from year to year.

A list of the strategies considered in this narrative:[1]

- Crop idling for water transfers
- Dewvaporation or atmospheric pressure desalination
- Fog collection
- Irrigated land retirement
- Rainfed agriculture
- Waterbag transport/storage technology

Crop Idling for Water Transfers

Crop idling is removal of lands from irrigation with the aim of returning the lands to irrigation at a later time. Crop idling for water transfers is done to make water available for transfer (See Volume 2, Chapter 23 for more information on water transfers). Crop idling may be done for a certain time or can be episodic. Land retirement for water transfer and for solving drainage and drainage-related problems is discussed in land retirement strategy later in this section. Crop idling, with the intent of soil and crop management and for soil and crop sustainability and productivity, is discussed in the agricultural lands stewardship strategy.

Crop Idling Programs

Westlands Water District Lease Back Program – The WWD has implemented a lease-back land fallowing program for about 30,000 acres. These lands are expected to be returned to irrigation if the U.S. Bureau of Reclamation provides drainage service to the lands.

Palo Verde Irrigation District Land Management, Crop Rotation, and Water Supply Program – This crop idling program helps provide more reliable water supply for urban Southern California, while helping Palo Verde Irrigation District farmers and local economy. PVID's program includes crop idling of predetermined duration. The principles of the proposed agreement followed a pilot program from 1992 to 1994. Under the pilot program, MWD compensated farmers for setting aside a portion of the land for two years, in return for the water that otherwise would have been used to grow hay, cotton, or other field crops. Program participants reported spending 90 percent of the money on farm-related investments, purchases, and debt repayment.

[1] Note that the quantity and specificity of information varies between strategies. This is solely due to the amount of information available to staff and does not imply any relative efficacy of the strategies.

Wetlands Reserve Program – The objective of the Wetlands Reserve Program (WRP) is to preserve and enhance the nation's wetlands. Under the WRP, willing farmers sell long-term agricultural production easements to the federal government. The WRP may result in improving quality of drainage waters from irrigated lands and thus benefits agriculture.

Summer Alfalfa Dry-down Research Program – This is an episodic event. Alfalfa summer dry-down is the practice of cutting off irrigation for one or two summer months and then reapplying water again in the fall when temperatures are cooler. The water saved during this period can be transferred to other uses. The yield and quality of the summer cuttings is low. Early alfalfa production in the desert regions used alfalfa summer dry-down to control weeds and conserve water. This program is currently under research and development. Alfalfa summer dry-down offers a unique tool for drought water management for several reasons. The program has potentially large water savings; 1 acre-foot per acre or 0.5 million acre-feet to 1 million acre-feet statewide. Net water savings can be easily verified. Water storage and transfer decisions can be made as late as June. Yield is generally reduced by only 20 to 40 percent, which diminishes the impact of crop idling on local communities. Research on alfalfa summer dry-down over the past 15 years has had mixed results with crop loss being the major limitation.

Potential Benefits

Crop idling could enhance water supply reliability by making water available for redistribution, enhance water quality, and protect and restore fish and wildlife. The water made available from crop idling depends on how long irrigation is interrupted. Palo Verde Irrigation District Land Management Program is expected to have an estimated annual water supply of 25,000 acre-feet to 111,000 acre-feet for transfer to MWD.

The crop idling program helps the farming community as well as urban areas, infusing money into the local economy, while increasing the reliability of water supplies for urban consumers. Avoided costs of new water supply should also be considered in the costs and benefit analysis of crop idling. Payments to farmers would provide stable income that can be used on farm-related investments, purchases and debt repayment and for local community improvement programs.

Potential Costs

Costs include loss of crop productivity and the annual cost of managing the lands to avoid negative impacts. Additional costs can include program development, administration, and mitigation of local and regional socioeconomic impacts.

Major Issues Facing Crop Idling

Socioeconomic Impacts

Loss of agricultural productivity and loss of revenue to the local communities and regional and statewide socioeconomic impacts are issues of concern. Crop idling can significantly change the local population's way of life. It can cause loss of local tax base, community businesses and farm related jobs locally and regionally. The third-party impacts can be significant, especially when crop idling is concentrated in areas where the communities provide labor and other services. If significant amount of land is idled it can also have a statewide impact on the economies, food production, and food security.

Environmental Impacts

Land use changes can impact neighboring land and its productivity. It can cause introduction of new wildlife species, weeds, pests, illegal dumping of refuse. It can affect the disposition of water and water rights issues and alter resources such as soils, groundwater, surface waters, cultural resources, recreation, biological including human health, dust and air quality. In addition, communities that serve agricultural activities inherently have high percentage of low income and disadvantaged groups that can be affected by the crop idling. Cumulative effects of short- and long-term crop-idling could have impacts on habitat, water quality, and wildlife caused by changing the location, timing, and quantity of applied water, and reducing agricultural returns flows to wildlife areas. For example, rice growing areas could have significant secondary benefits as wildlife habitat. Crop idling in these areas could either harm or benefit different species depending on implementation.

Recommendations to Encourage Crop Idling Programs to Benefit Water Management Strategy

1. The agency or entity leading the crop idling program must begin early consultation with other agencies and develop the necessary coordination structure to satisfy the agency policy requirements and avoid conflicts.
2. Study local community impacts and other third-party impacts and develop and implement the necessary actions for maintaining the economic stability of local communities and mitigation of socioeconomic impacts.

Dewvaporation or Atmospheric Pressure Desalination

Dewvaporation is a specific process of humidification-dehumidification desalination. Brackish water is evaporated by heated air, which deposits fresh water as dew on the opposite side of a heat transfer wall. The energy needed for evaporation is supplied by the energy released from dew formation. Heat sources can be combustible fuel, solar or waste heat. The tower unit is built of thin plastic films to avoid corrosion and to minimize equipment costs. Towers are relatively inexpensive since they operate at atmospheric pressure.

Dewvaporation in California

The technology of dewvaporation is still being developed. Final demonstration project towers have been built and operated at Arizona State University (ASU) laboratories. The Salt River Project and the ASU Office of Technology Collaborations and Licensing are sponsoring the dewvaporation pilot plant program as an extension of grassroots support by the U.S. Bureau of Reclamation.

Potential Benefits

Dewvaporation can provide small amounts of water in remote locations. The basic laboratory test unit produces to 150 gallons per day. Eight of these units form a 1,000-gallons-per-day demonstration pilot plant of the dewvaporation process.

Areas such as Yuma, Arizona, and the desert regions of California could reclaim salt water at relatively low cost by taking advantage of their dry climates.

Potential Costs

The capital cost of 1,000 gallon per day desalination plant can range between $1,100 and $2,000. Operating costs range from $0.80 to $3.70 per 1,000 gallons distillate, or about $260 to $1,200 per acre-foot, depending on fuel source, humidity levels and plant size.

Major Issues Facing Dewvaporation

1. Cost and affordability
2. Small scale
3. Concentrate disposal

Fog Collection

Precipitation enhancement also includes other methods, such as physical structures or nets to induce and collect precipitation.

Fog Collection in California

Precipitation enhancement in the form of fog collection has not been used in California as a management technique but does occur naturally with coastal vegetation; fog provides an important portion of summer moisture to our coastal redwoods.

Potential Benefits

There has been some interest in fog collection for domestic water supply in some of the dry areas of the world near the ocean where fog is frequent. Some experimental projects have been built in Chile, and have been considered in some parts of the Middle East and South Africa. The El Tofo project in Chile yielded about 10,600 liters per day from about 3,500 square meters of collection net, about 3 liters per day per square meter of net. Because of its relatively small production, fog collection is limited to producing domestic water where little other viable water sources are available.

Potential Costs

The lowest costs for fog collection in Chile, where labor is much less expensive than California, were about $1.40 per 1,000 liters, or about $1,750 per acre-foot.

Irrigated Land Retirement

Irrigated land retirement is the removal of farmland from irrigated agriculture. The permanent land retirement is perpetual cessation of irrigation of lands from agricultural production, which is done for water transfer or for solving drainage-related problems. (See Volume 2, Chapter 23 for more information on water transfers). Crop idling, or land fallowing, for crop management and for soil and crop sustainability and productivity is discussed in the agricultural lands stewardship strategy. Crop idling, with the intent of water transfer, is discussed in crop idling strategy.

Irrigated Land Retirement in California

Central Valley Project Improvement Act Land Retirement Program – The 1992 Central Valley Project Improvement Act authorized purchase from willing sellers, of agricultural land and associated water rights and other property interests which receive CVP water. The program is expected to retire about 100,000 acres of irrigated farmland.

The U.S. Bureau of Reclamation initiated the Land Retirement Demonstration Project. So far, this program has retired about 8,300 acres of land in the Westlands Water District and the Tulare Lake Basin.

CVPIA Land Retirement Program Applies to lands that:

- *Would improve water conservation or improve the quality of an irrigation district's agricultural drainage water*

  Or
- *Are no longer suitable for sustained agricultural production because of permanent damage resulting from severe agricultural drainage water management problems, groundwater withdrawals, or other causes*

Reclamation's Settlement Agreements – About 3,000 acres of drainage problem lands in WWD have been retired as a part of Britz vs. U.S. Bureau of Reclamation settlement. Also, 33,000 acres in the WWD over a three-year period are planned to be retired, Sumner-Peck vs. U.S. Bureau of Reclamation. These lands have been permanently retired and the associated water allocation is given to WWD under an agreement.

Potential Benefits

Land retirement could enhance water supply reliability by making water available for redistribution, enhance water quality, and protect and restore fish and wildlife resources, but it results in loss of agricultural lands. The total water made available by irrigated land retirement is potentially 2 to 3.5 acre-feet per year for each retired acre, assuming the lands are receiving their water allocation.

Permanent land retirement in problem drainage areas would improve water quality, specifically reducing the risk of selenium exposure to fish and wildlife. Permanent land retirement can reduce drainage volume annually by about 0.3-0.5 acre-feet per acre, reducing the costs associated with drainage disposal. Permanent retirement of lands also creates an opportunity to establish upland or other habitat for wildlife.

Potential Costs

Costs include price of lands and the annual cost of managing the lands to avoid environmental impacts. Additional costs may include program development, administration, and mitigation of local and regional socioeconomic impacts.

Major Issues Facing Land Retirement

Willing Participant — Land retirement is voluntary, and many farmers may lack the desire sell their land and abandon their way of life.

Growth Inducement of Land Retirement — Land retirement could result in urban growth when water from retired lands is made available to urban areas.

Socioeconomic Impacts — Loss of agricultural productivity and loss of revenue to the local communities and regional and statewide socioeconomic impacts are issues of concern. Land retirement can significantly change the local population's way of life. It can cause loss of local tax base, community businesses and farm related jobs locally and regionally. The third-party impacts can be significant, especially when land retirement is concentrated in areas where the communities provide labor and other services. If significant amount of land is retired it can also have a statewide impact on the economy, food production, and food security.

Environmental Impacts — Land use changes can impact neighboring land and its productivity. It can cause introduction of new wildlife species, weeds, pests, and illegal dumping of refuse. It can affect the water rights issues and alter resources such as soils, groundwater, surface waters, cultural resources, recreation, biological including human health, dust and air quality. In addition, communities that serve agricultural activities inherently have high percentage of low income and disadvantaged groups that can be affected by land retirement. Cumulative effects of land retirement could have impacts on habitat, water quality, and wildlife caused by changing the location, timing, and quantity of applied water, and reducing agricultural returns flows to wildlife areas. Land retirement could either harm or benefit different species depending on what the land use is changed to.

Recommendations to Facilitate Land Retirement Programs to Benefit Water Management

1. The agency or entity leading the land retirement program must begin early consultation with other interested agencies and develop the necessary coordination structure to satisfy the agency policy requirements and avoid conflicts.
2. The land purchase price has to be fair and costs associated with the mitigation of all impacts must be considered in developing the program. Land retirement programs must be voluntary.
3. Since alternative land use management scenarios may achieve similar objectives, alternatives to permanent retirement to achieve the same objectives should be considered in developing land retirement programs. Also, there is a need to assist local water agencies with using land retirement as appropriate for local conditions for State and local benefits.

This may include voluntary integration of land fallowing with conjunctive use and water exchange and transfers. When retiring lands, give the highest priority to lands with poor quality, low productivity, and high trace element contents.

4. The lead agency must evaluate the growth inducement impacts of the program and ensure that the urban area receiving the water made available by land retirement has exhausted means of reasonable water conservation, it doesn't induce growth, and the water from land retirement will be put to reasonable and beneficial uses.
5. Study local community impacts and other third party impacts and develop and implement the necessary actions for maintaining the economic stability of local communities and mitigation of socioeconomic impacts.
6. Study regional impacts resulting from land retirement including impacts from reduced agricultural production inputs and reduced farm income, income received from land payments and habitat restoration.
7. Land retirement must comply with the CEQA. The land retirement programs must include fair treatment of people of all races, cultures and incomes with respect to the development, adoption, implementation, and enforcement of environmental laws, regulations, and policies.

Rainfed Agriculture

Rainfed agriculture is when all crop consumptive water use is provided directly by rainfall on a real time basis. Due to unpredictability of rainfall frequency, duration, and amount, there is significant uncertainty and risk in relying solely on rainfed agriculture. This is especially true in California, where there is little or no precipitation during most of the spring and summer growing season.

Current Extent of Rainfed Agriculture in California

Climatic conditions in California provide excellent conditions for crop production; little cloud cover provides ample solar radiation during the spring and summer growing season. Precipitation in the form of rainfall and snow occurs mainly during the fall and winter months. However, the lack of sufficient and timely rainfall during the spring and summer in much of California severely limits the potential for expansion of rainfed agriculture.

In California's interior, north coast, and central coast, winter crops directly use rain water with the help of more irrigation water during the latter part of the winter season, if needed. These areas provide a relatively high return from the high value winter crops such as vegetables in the coastal areas. Other important agricultural production sectors that are dependent on rainfall are pastoral areas, rangelands, and rolling hills in the state. These areas produce significant amounts of feed and provide grazing areas for the state's large cattle (dairy and meat) industry. Winter small grains crops, such as winter wheat, account for about 4 percent (400,000 acres) of agricultural lands and provide a relatively small contribution to the state's total agricultural economy.

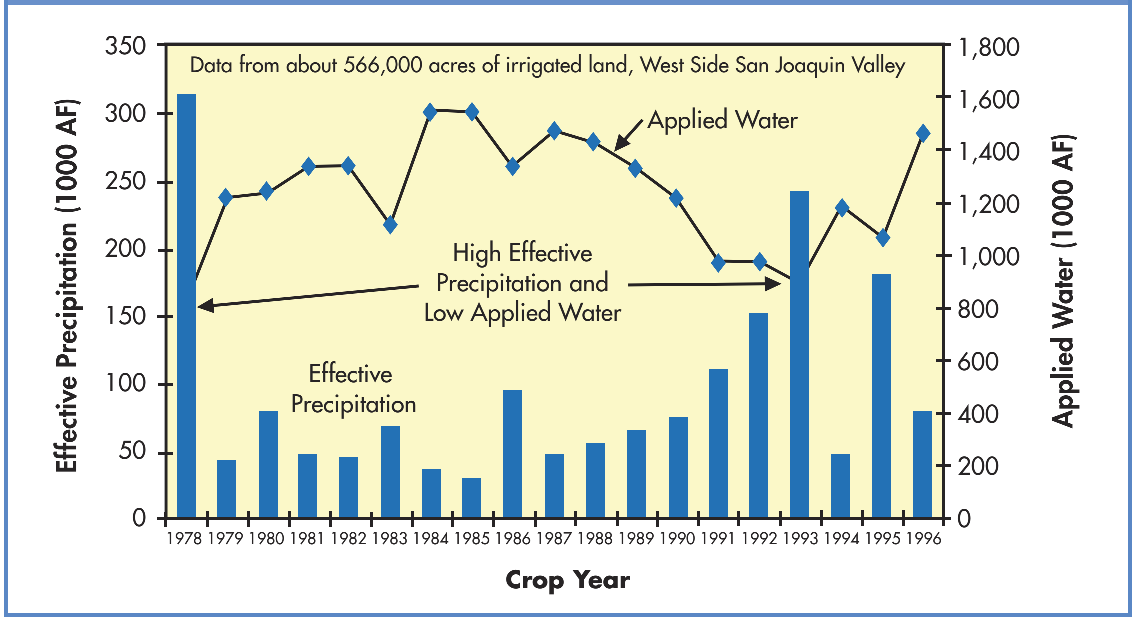
The vast majority of California's agricultural production requires irrigation. Rainfall that occurs before irrigation season and during the irrigation season can reduce irrigation water requirements. During years with heavy springtime rains, soil moisture remains higher for longer periods of time and can measurably reduce irrigation requirements for the year. Growers and water districts factor effective rainfall into their water management practices. In addition, DWR's water balance calculations for each region account for the portion of crop water requirements provided directly by rainfall.

As demonstrated in Figure 26-1, applied water and rainfall events are closely related. More rainfall, particularly during early growing season, provides a significant quantity of effective rainfall for crop consumptive use. The figure shows the inverse relationships between effective rainfall and applied water. Based on the 18 years (1978-1996) of data for an area on the west side San Joaquin Valley, effective rainfall provided an average of 7 percent of the total crop consumptive use. In 1978 and 1993, two wet years with early season rainfall, effective rainfall amounted to 27 and 21 percent respectively of the crop consumptive use. In 1990, a dry year, effective rainfall amounted to only 3 percent of the total crop consumptive use. Similar examples can be given for other regions of the state.

Potential Benefits

Currently, improvements in the rainfed agricultural production offer limited water supply opportunity in California. More acreage for production of winter crops will reduce runoff flowing in the surface water systems and to ocean outflows. Improvements in rangelands and grazing areas through improved plant varieties can provide crop yield benefits but not significant water supply opportunities. One important aspect of improved rainfed agriculture is a better post harvest/pre-planting soil management for winter crops such as wheat. Many winter wheat growers are already implementing adequate and prudent soil management practices for water and erosion manage-

Figure 26-1 Effective precipitation and applied water



ment. Land that is tilled and left fallow after harvest can cause the soil surface to seal with the first and second rainfall and increase runoff and erosion. Improved tillage practices, no-till or minimum-till, may improve water infiltration into soil root zone, thus increasing soil-water storage and could contribute to water supply by eliminating the first seasonal irrigation. Additionally, increased soil moisture reduces soil erosion; helps improve water quality and may help increase water use efficiency and economic efficiency. Advances in plant genetics to provide higher crop yields from direct rainfall could replace some crops that rely on irrigation.

Quantification of potential water savings from improved rainfed agriculture, while very small, is not possible due to lack of information.

Potential Costs

Potential cost consists of on-farm soil management and cost of research and development, demonstration and educational and training and dissemination of information and technologies. On-farm cost is an integral part of soil management that is already part of grower's practices. Soil management practices may need to be adjusted for timing with no additional or minimal cost. Cost of research, development, demonstration, education, and training and dissemination of new information and tillage management technologies will need to be paid by the State. It is possible that such activities can be funded from CALFED Water Use Efficiency loans and grants.

Major Issues Facing Additional Rainfed Agriculture

While rainfed agriculture provides some opportunity for increasing yield and water supply reliability, the efforts will likely result in insignificant and unquantifiable contributions to the water supply. However, increases in yields for winter crops and winter cover crops can be significant and benefit overall water management in California. Water supply Improvements would require development of new varieties of plants, new and innovative soil and water management. A major issue is that quantification of water savings cannot be made at the present time. Also, this strategy does not provide water supply benefits on a real time basis. For example, improvements in soil management may provide future benefit in storing more rainfall in the root zone if future uncertain and unpredictable weather conditions prevail.

Recommendations to Increase Water Use Efficiency in Rainfed Agriculture

Following is a list of recommendations to increase water use efficiency in the rainfed agriculture:

1. Develop improved varieties of winter rainfed crops, such as wheat, other small grains, cover crops, and winter crops. This can be achieved by providing financial resources to the state's research and development institutions to develop new and improved varieties. In addition, develop research and demonstration of innovative water management

practices where growers with marginal lands and marginal production may shift from irrigated agricultures to rainfed winter crops.

2. Provide technical and financial assistance to promote no-till or minimum-till practices by growers who prepare their lands for planting during spring, but leave it fallow during the fall and winter. Cooperative efforts with the state's research and development institutions can benefit this important aspect of rainfed agriculture.
3. Develop new and innovative technologies, management, and efficient water management practices for rainfed agriculture, particularly winter wheat.
4. Provide technical and financial assistance to implement technologies, and management practices for rainfed agriculture.
5. Develop and promote new and innovative activities and management practices for intensive and managed grazing.
6. Maximize, collect, and store runoff from rainfed agriculture and develop cooperative efforts to link runoff from rainfed agriculture and water banking and conjunctive use activities and groundwater recharge.
7. Disseminate practical information through educational and training opportunities.

Waterbag Transport/Storage Technology

The use of waterbag transport/storage technology involves diverting water in areas that have unallocated fresh water supplies, storing the water in large inflatable bladders, and towing to an alternate coastal region. Fresh water is lighter than seawater, which makes the bags float on the surface. This makes them easier to tow. After discharging their contents, empty bags are then reeled to the deck of the tug allowing for a more speedy return to the source water area.

Use of Waterbag Transport/ Storage Technology

Although this strategy is not currently being used in California, there have been several proposals to implement this technology throughout the world. The most recent was the proposal by Alaska Water Exports Company to divert up to 30,000 acre-feet from the Albion and Gualala River Rivers in Northern California and transport the water to the San Diego metropolitan area. The proposal received significant local opposition in Northern California.

Potential Benefits

- Provide water supply benefit
- Improve drought preparedness
- Improve water quality
- Operational flex and efficiency
- Environmental benefits
- Energy benefits
- Reduce groundwater overdraft

Potential Costs

The total cost for waterbag transport is highly project specific and contingent upon several factors such as facility costs for diverting and off-loading water, environmental mitigation, administrative costs, cost to construct bags, and towing costs.

Issues Facing Waterbag Transport/ Storage Technology

Third-Party Impacts — Similar to any other type of transfer, impacts on the area of origin may occur. This includes projects that use "surplus" water and using water that is currently being put to a beneficial use. Other issues of concern expressed to proponents of recent projects include aesthetics and noise pollution from diversion facilities and the dissatisfaction within area of origin communities that others are exporting a local resource.

Environmental Impacts — Although most proposed diversions for waterbag transport take place near the mouth of a source river, facilities may need to be built to convey the water from a significant distance upstream (e.g. before blending with high salinity ocean water). Some areas may already have conveyance facilities in place that could be accessed for waterbag storage and transport.

Selected References

Crop Idling for Water Transfers

WWD Land Retirement Program: www.westlandswater.org/drainage/drainage1.htm

Palo Verde Irrigation District Land Management Program: www.mwdh2o.com/mwdh2o/pages/yourwater/supply/paloverde01.html

Dewvaporation or Atmospheric Pressure Desalination

Beckman, James. R., Arizona State University, Tempe, Arizona, and U.S. Bureau of Reclamation. "Carrier Gas Enhanced Atmospheric Pressure Desalination." Final Report. October 2002.

Fog Collection

Proceedings of the Second International Conference on Fog and Fog Collection, P.O. Box 81541 Toronto, Ontario, Canada, July 2001.

Irrigated Land Retirement

WWD Land Retirement Program: www.westlandswater.org/drainage/drainage1.htm

Land Retirement Guidelines, USBR, www.mp.usbr.gov/cvpia/lrgdln97.pdf

The San Joaquin Valley Drainage Program 1990 Report (the Rainbow Report) and other reports: www.owue.water.ca.gov/statedrain/pubs/pubs.cfm

The San Joaquin Valley Drainage Implementation Program www.owue.water.ca.gov/statedrain/index.cfm

The Land Retirement Report- SJVDIP

The USBR San Luis Drainage Feature Reevaluation and EIS www.mp.usbr.gov/sccao/sld/index.html

Drainage Without a Drain. The Bay Institute et al. www.bay.org

Rainfed Agriculture

Local agencies (reports and publications)

Local farm advisors and UC System

Federal Bureau of Land Management and National Forest Service

Private rangeland owners and relevant associations of rangeland managers/owners

United States Department of Agriculture, ARS State educational institutions (Fresno CIT, Cal Poly, etc.)

Published technical and scientific papers

California Cattlemen Association

Commodity groups

Ranches

Information from best professional/scientific assessment/ judgment of DWR's staff and others

Waterbag Transport/Storage Technology

Wang, Ucilia. "Plan to export Gualala, Albion water to Southern California drew heat on North Coast". Santa Rosa Press Democrat. December 14, 2002.

Volume 2

Glossary, and Metric Conversion Table

Glossary

A

acre-foot (af) – The volume of water that would cover one acre to a depth of one foot; equal to 43,560 cubic feet or 325,851 gallons.

adjudication –The act of judging or deciding by law. In the context of an adjudicated groundwater basin, landowners or other parties have turned to the courts to settle disputes over how much groundwater can be extracted by each party to the decision.

agricultural discharge standards – State and federal water quality regulations regarding discharge of water used for agricultural production to streams, rivers, groundwater aquifers, or evaporation ponds. Context: Scenario Factor.

agricultural lands stewardship – Conserving natural resources and protecting the environment by compensating owners of private farms and ranches for implementing stewardship practices. Context: Resource Management Strategy.

agriculture water reliability (average) – A measure of a water system's ability to sustain the social, environmental, and economic agricultural systems that it serves during a year of average precipitation

agricultural water use efficiency – The ratio of applied water to the amount of water required to sustain agricultural productivity. Efficiency is increased through the application of less water to achieve the same beneficial productivity or by achieving more productivity while applying the same amount of water. Context: Scenario Factor, Resource Management Strategy.

allocation of long-term contractual imports – Interregional allocation of water for periods of time more than one year through mechanisms such as the State and federal water projects. Context: Scenario Factor.

alluvial – Of or pertaining to or composed of alluvium.

alluvium – A general term for clay, silt, sand, gravel, or similar unconsolidated detrital material, deposited during comparatively recent geologic time by a stream or other body of running water, as a sorted or semi-sorted sediment in the bed of the stream or on its floodplain or delta, as a cone or fan at the base of a mountain slope.

anthropogenic – Of human origin or resulting from human activity.

applied water – The amount of water from any source needed to meet the demand for beneficial use by the user. It includes consumptive use, reuse, and outflows.

applied water reduction – A decrease in the amount of water needed to meet the demand for beneficial use; can be a supply for both new (real) water and reused water. Context: Resource Management Strategy. See also new water.

appropriative right – The right to use water that is diverted or extracted by a nonriparian or nonoverlying party for nonriparian or nonoverlying beneficial uses. In California, surface water appropriative rights are subject to a statutory permitting process while groundwater appropriation is not.

aquifer – A body of rock or sediment that is sufficiently porous and permeable to store, transmit, and yield significant (i.e. economic) quantities of groundwater to wells and springs.

aquifer remediation – See groundwater remediation/aquifer remediation

aquitard – A confining bed or formation composed of rock or sediment that retards but does not prevent the flow of water to or from an adjacent aquifer. It does not readily yield water to wells or springs, but stores groundwater.

artesian aquifer – A body of rock or sediment containing groundwater that is under greater than hydrostatic pressure; that is, a confined aquifer. When an artesian aquifer is penetrated by a well, the water level will rise above the top of the aquifer.

artesian pressure – Hydrostatic pressure of artesian water, often expressed in terms of pounds per square inch; or the height, in feet above the land surface, of a column of water that would be supported by the pressure.

artificial recharge – The (intentional) addition of water to a groundwater reservoir by human activity, such as putting surface water into dug or constructed spreading basins or injecting water through wells.

available groundwater storage capacity – The volume of a groundwater basin that is unsaturated and capable of storing groundwater.

available soil water – The amount of water held in the soil that can be extracted by a crop; often expressed in inches per foot of soil depth. It is the amount of water released between in situ field capacity and the permanent wilting point.

average annual cost of implementing option – Annualized total monetary cost of option required for "turn key" implementation including environmental and third party impact mitigation, storage, conveyance, energy, capitalized operations and maintenance, administrative, planning, legal and engineering costs. Context: Evaluation Criteria; Planning Concept/Consideration.

average annual runoff – The average value of total annual runoff volume calculated for a selected period of record, at a specified location, such as a dam or stream gage.

average year water demand – Demand for water under average hydrologic conditions for a specific level of development.

B

basin irrigation – Irrigation by flooding areas of level land surrounded by dikes. Used interchangeably with level border irrigation, but usually refers to smaller areas.

basin management objectives (BMOs) – See management objectives

beneficial use – Use of water either directly by people or for their overall benefit. There are 24 categories of beneficial uses identified by the State Water Resources Control Board.

border irrigation – Irrigation by flooding strips of land, rectangular in shape and cross leveled, bordered by dikes. Water is applied at a rate sufficient to move it down the strip in a uniform sheet. Border strips having no downfield slope are referred to as level border systems. Border systems constructed on terraced lands are commonly referred to as benched borders.

C

catastrophic vulnerability – The probability and magnitude of potential negative economic, public health, and environmental impacts associated with water management actions. Context: Scenario Factor, Evaluation Criteria..

Central Valley Project deliveries – The volume of water imported to a given area through the Central Valley Project. Context: Scenario Factor.

check irrigation – Modification of a border strip with small earth ridges or restrictions (checks) constructed or inserted at intervals to retain water as it flows down the strip.

CIMIS – California Irrigation Management Information System- A network of automated weather stations that are owned and operated cooperatively between the DWR and local agencies. The stations are installed in most of the agricultural and urban areas in the State and provide farm and large landscape irrigation managers and researchers with "real-time" weather data to estimate crop and landscape ET rates and make irrigation management decisions.

climate change – Changes in average annual temperature and precipitation and their monthly patterns in 2050 compared to today.

Colorado River supply – The volume of water California has the right to import from the Colorado River. California's allocation is 4.4 million acre-feet per year plus 50% of any declared surplus. Context: Scenario Factor.

commercial activity mix – The mix of high- and low-water using commercial activity. Note that commercial activity is broken into two factors: total commercial activity and commercial activity mix. The latter factor allows designation of the type of commercial activity that is occurring. See also total commercial activity. Context: Scenario Factor.

community water system – A public water system that serves at least 15 service connections used by yearlong residents or regularly serves at least 25 yearlong residents. See also public water system.

consumed fraction – the portion of agricultural applied irrigation water that satisfies evapotranspiration.

conveyance – Provides for the movement of water and includes the use of natural and constructed facilities including open channels, pipelines, diversions, fish screens distribution systems and pump lifts.

conveyance facilities – Canals, pipelines, pump lifts, ditches, etc. used to move water from one area to another. Context: Study Plan Building Block, Resource Management Strategy.

confined aquifer – An aquifer that is bounded above and below by formations of distinctly lower permeability than that of the aquifer itself. An aquifer containing confined groundwater. See also artesian aquifer.

conjunctive management and groundwater storage – Coordinated operation of surface water storage and use, ground water storage and use, and conveyance facilities. Context: Resource Management Strategy.

conjunctive use – Application of surface and groundwater to meet the demand for a beneficial use. Coordinated and planned management of both surface and groundwater resources in order to maximize the efficient use of the resource; that is, the planned and managed operation of a groundwater basin and a surface water storage system combined through a coordinated conveyance infrastructure. Water is stored in the groundwater basin for later and planned use by intentionally recharging the basin during years of above-average surface water supply.

conservation tillage – A tillage practice that leaves plant residues on the soil surface for erosion control and moisture conservation

consumptive use – A quantity of applied water that is not available for immediate or economical reuse. It includes water that evaporates, transpires, or is incorporated into products, plant tissue, or animal tissue. Consumptively used water is removed from available supplies without return to a water resource system (uses such as manufacturing, agriculture, landscaping, food preparation, and in the case of Colorado River water, water that is not returned to the river.)

contaminant – Any substance or property preventing the use or reducing the usability of the water for ordinary purposes such as drinking, preparing food, bathing washing, recreation, and cooling. Any solute or cause of change in physical properties that renders water unfit for a given use. (Generally considered synonymous with pollutant.)

cost recovery – Designates who (marginal or existing users) pays the marginal and existing water costs. Also specifies cir cumstances where other revenue sources are used to recover costs. Costs can include capital, O&M, financing, environmental compliance (documentation, permitting and mitigation), etc. Context: Scenario Factor

cost of reliability enhancement – The total cost required to add an increment of reliability. Context: Evaluation Criteria.

cost of unreliability – The sum of the forgone long-term value and short-term costs incurred to the users. Context: Evaluation Criteria

critical conditions of overdraft – A groundwater basin in which continuation of present practices would probably result in significant adverse overdraft-related environmental, social, or economic impacts. The definition was created after an extensive public input process during the development of the Bulletin 118-80 report.

cover crop – Close growing crop, that provides soil protection, seeding protection, and soil improvement between periods of normal crop production, or between trees in orchards and vines in vineyards. When plowed under and incorporated into the soil, cover crops may be referred to as green manure crops.

crop coefficient – A numerical factor (normally identified as Kp or Kc) that relates the evapotranspiration (ET) of the individual crop (ETc) to reference evaporation or some other index.

crop idling – The temporary or permanent fallowing of land previously under irrigation that results in a reduction in stresses to a water system (e.g., alternate land use must result in a reduction in water use and/or enhancement of water quality, etc.). Context: Scenario Factor.

crop rotation – A system of farming in which a succession of different crops are planted on the same land area, as opposed to growing the same crop time after time (monoculture).

crop unit water use –The volume of irrigation water used per unit area of land, commonly expressed in acre feet per acre. As used in scenario evaluation, a change in unit water use can be a function of evapotranspiration rates and cultural practices, but NOT use efficiency. Agricultural use efficiency is captured under its own distinct factor. Context: Scenario Factor.

D

deep percolation – Percolation of water through the ground and beyond the lower limit of the root zone of plants into groundwater

deep percolation of surface and groundwater – Water that is applied for agricultural, urban, and managed wetlands in excess of the net use requirements. Water either is applied for groundwater recharge or percolates naturally to the water table. This does not include reuse, evaporation, evapotranspiration of applied water, or flows/percolation to a salt sink. Context: Water Portfolio

depletion – Water consumed through evapotranspiration, flows to salt sinks or is otherwise no longer available as a source supply.

desalination – Water treatment process for the removal of salt from water for beneficial use. Source water can be brackish (low salinity) or seawater. Context: Study Plan Building Block.

dewvaporation (Atmospheric Pressure Desalination) – Desalination through humidification and subsequent dehumidification (collection of evaporated water). Context: Resource Management strategy.

distribution system – System of ditches or conduits and their controls that conveys water from the supply canal to the farm points of delivery domestic well – A water well used to supply water for the domestic needs of an individual residence or systems of four or fewer service connections.

drinking water standards – State and federal regulations regarding water delivered by water purveyors that is used as a potable supply. Context: Scenario Factor.

drinking water system – see public water system

drinking water treatment and distribution – Treatment is the physical, biological and chemical processes that make water suitable for potable use. Distribution includes storage, pumping, and pipe systems to protect and deliver the treated water to customers. Context: Study Plan Building Block.

drip irrigation – A method of micro irrigation wherein water is applied to the soil surface as drops or small streams through emitters. Discharge rates are generally less than 8 L/h (2 gal/h) for a single-outlet emitters and 12 L/h (3 gal/h) per meter for line-source emitters.

drought preparedness– The magnitude and probability of economic, social or environmental consequences that would occur as a result of a sustained drought under a given study plan. Evaluation criteria measure the "drought tolerance" of study plans. Context: Water Management Objective

drought condition – Hydrologic conditions during a defined period, greater than one dry year, when precipitation and runoff are much less than average.

drought year supply – The average annual supply of a water development system during a defined drought period.

duty of water – The total volume of irrigation water required to mature a particular type of crop. It includes consumptive use, evaporation, and seepage as well as the water returned to streams by percolation and surface water.

E

earthquake vulnerability – see seismic vulnerability

economic incentives – Financial assistance and pricing policies intended to influence water management including, for example, amount of use, time of use wastewater volume, and source of supply. Context: Resource Management Strategy.

ecosystem restoration – The activity of improving the condition of natural landscapes and biotic communities. Context: Study Plan Building Block.

effective precipitation – That portion of precipitation that supplies crop evapotranspiration. It includes precipitation stored in the soil before and during the growing season

effective porosity – The volume of voids or open spaces in alluvium and rocks that is interconnected and can transmit fluids.

effective rooting depth – The depth from which soil moisture is extracted; it is determined by the crop rooting characteristics and soil depth limitations.

electrical conductivity (EC) – The measure of the ability of water to conduct an electrical current, the magnitude of which depends on the dissolved mineral content of the water.

energy availability – The energy consumption to facilitate water management-related actions such as desalting, pump-storage, groundwater extraction, conveyance or treatment. This criterion pertains to the economic feasibility of a proposed water management action in terms of O&M costs. Context: Evaluation Criteria.

energy costs – Refers to the cost of energy use related to producing, conveying and applying water. It also refers to the cost of energy use for processes and inputs not directly related to water, but which can affect the demand for water (e.g., the cost of nitrogen fertilizer, tractor manufacturing, etc.). Context: Scenario Factor.

energy production – Both instantaneous capacity (megawatt) and energy produced (kilowatt hours). Context: Evaluation Criteria.

environmental justice – The fair treatment of people of all races, cultures, and incomes with respect to the development, adoption, implementation, and enforcement of environmental laws, regulations, and policies. (Section 65040.12. (c) Government code)

environmental water (flow based) – The amount of water dedicated to instream fishery uses, Wild and Scenic rivers, Bay-Delta outflow and aquatic habitat.

environmental water (land based) – The amount of water used for fresh-water managed wetlands and native vegetation.

environmental water quality – Water quality in terms of ecosystem health, recreation, salinity intrusion, usability per sector, treatment costs, etc. Aquatic species and water bodies are vulnerable to changes to water quality.

ETo (Reference Evapotranspiration) – The evapotranspiration rate from an extended surface of 3 to 6 inch (8–15 cm) tall green grass cover of uniform height, actively growing, completely shading the ground, and not short on water (the reference ET reported by CIMIS).

evaluation criteria – The technical information that will be used to compare the favorability of different response packages of resource management strategies against future scenarios in California Water Plan Update 2010. They are designed to identify and measure potential effects on water supply, the environment, energy use or production, recreational opportunities, groundwater overdraft, and many more.

evaporation – The physical process by which a liquid or solid is transformed to a gaseous state.

evaporative demand – The collective influence of all climatic factors on the rate of evaporation of water.

evapotranspiration (ET) – The quantity of water transpired by plants, retained in plant tissues, and evaporated from plant tissues and surrounding soil surfaces

evapotranspiration of applied water (ETAW) – The portion of ET satisfied by applied irrigation water.

F

flood irrigation – Method of irrigation where water is applied to the soil surface without flow controls, such as furrows, borders, or corrugations

floodplain management – Actions designed to reduce risks to life, property, and the environment due to flooding. Actions can include watershed management, infrastructure construction and operation, variations in land use practices, floodway designations, etc. Context: Study Plan Building Block.

flood risk – The magnitude and probability of consequences that would occur as a result of flood-induced infrastructure damage under a given study plan. Context: Evaluation Criteria.

flow diagram – Diagram that characterizes a region's hydrologic cycle by documenting sources of water such as precipitation and inflows and tracks the water as it flows (through many different uses) to its ultimate destinations.

flow diagram table – An itemized listing of all the categories contained in the Flow Diagram including more detailed information, organized by "inputs" and "withdrawals."

full cost – (1) all monetary costs associated with project planning, implementation, financing, or impact mitigation plus any recurring costs required to sustain benefits; PLUS (2) all nonmonetary costs that are incurred either at implementation or on a recurring basis such as unmitigable environmental or cultural impacts, public trust, environmental justice, or other nonmarket-based societal values. (Coincides with CEQA/NEPA study and other permitting requirements.) Context: Planning Concept/Consideration.

furrow irrigation – Method of surface irrigation where the water is supplied to small ditches or furrows for guiding across the field.

G

groundwater – Water that occurs beneath the land surface and fills the pore spaces of the alluvium, soil, or rock formation in which it is situated. It excludes soil moisture, which refers to water held by capillary action in the upper unsaturated zones of soil or rock.

groundwater basin – An alluvial aquifer or a stacked series of alluvial aquifers with reasonably well-defined boundaries in a lateral direction and having a definable bottom.

groundwater budget – A numerical accounting, the groundwater equation, of the recharge, discharge and changes in storage of an aquifer, part of an aquifer, or a system of aquifers.

groundwater in storage – The quantity of water in the zone of saturation.

groundwater management – The planned and coordinated management of a groundwater basin or portion of a groundwater basin with a goal of long-term sustainability of the resource.

groundwater management plan – A comprehensive written document developed for the purpose of groundwater management and adopted by an agency having appropriate legal or statutory authority.

groundwater mining – The process, deliberate or inadvertent, of extracting groundwater from a source at a rate in excess of the replenishment rate such that the groundwater level declines persistently, threatening exhaustion of the supply or at least a decline of pumping levels to uneconomic depths.

groundwater monitoring network – A series of monitoring wells at appropriate locations and depths to effectively cover the area of interest. Scale and density of monitoring wells is dependent on the size and complexity of the area of interest, and the objective of monitoring.

groundwater overdraft – The condition of a groundwater basin in which the amount of water withdrawn by pumping exceeds the amount of water that recharges the basin over a period of years during which water supply conditions approximate average conditions.

groundwater quality – See water quality

groundwater recharge facility – A structure that serves to conduct surface water into the ground for the purpose of replenishing groundwater. The facility may consist of dug or constructed spreading basins, pits, ditches, furrows, streambed modifications, or injection wells.

groundwater recharge – The natural or intentional infiltration of surface water into the zone of saturation.

groundwater remediation/aquifer remediation – Groundwater Remediation involves extracting contaminated groundwater from an aquifer, treating it, and then either putting it back in the aquifer or using it for agricultural or municipal purposes. Aquifer Remediation is usually accomplished by treating groundwater while it is still in the aquifer, using in-situ methods involving biological, physical, or chemical treatment or electrokinetics. Context: Study Plan Building Block, Resource Management Strategy.

groundwater source area – An area where groundwater may be found in economically retrievable quantities outside of normally defined groundwater basins, generally referring to areas of fractured bedrock in foothill and mountainous terrain where groundwater development is based on successful well penetration through interconnecting fracture systems. Well yields are generally lower in fractured bedrock than wells within groundwater basins.

groundwater storage capacity – Volume of void space that can be occupied by water in a given volume of a formation, aquifer, or groundwater basin.

groundwater subbasin – A subdivision of a groundwater basin created by dividing the basin using geologic and hydrologic conditions or institutional boundaries.

groundwater table – The upper surface of the zone of saturation in an unconfined aquifer.

groundwater quality – Water quality can affect supply integrity. Many pollutants are hydrophilic and not easily filtered by soil. Treated groundwater can be added to water supply. Context: Evaluation Criteria.

H

hazardous waste – Waste that poses a present or potential danger to human beings or other organisms because it is toxic, flammable, radioactive, explosive, or has some other property that produces substantial risk to life.

hydraulic barrier – A barrier created by injecting fresh water to control seawater intrusion in an aquifer, or created by water injection to control migration of contaminants in an aquifer.

hydraulic conductivity – A measure of the capacity for a rock or soil to transmit water; generally has the units of feet/day or cm/sec.

hydrograph – A graph that shows some property of groundwater or surface water as a function of time at a given point.

hydrology – A science related to the occurrence and distribution of natural water on the earth including the annual volume and the monthly timing of runoff.

hydrologic cycle – The circulation of water from the ocean through the atmosphere to the land and ultimately back to the ocean.

hydrologic region – A study area consisting of multiple planning subareas. California is divided into 10 hydrologic regions.

hydrostratigraphy – A geologic framework consisting of a body of rock having considerable lateral extent and composing a reasonably distinct hydrologic system.

hyporheic zone – The region of saturated sediments beneath and beside the active channel and that contain some proportion of surface water that was part of the flow in the surface channel and went back underground and can mix with groundwater.

I

in-lieu recharge – The practice of providing surplus surface water to historic groundwater users, thereby leaving groundwater in storage for later use.

industrial activity mix – The mix of high and low water using industrial activity. Note that Industrial Activity is broken into two factors: Total Industrial Activity and Industrial Activity Mix. The latter factor allows designation of the type of industry that is occurring. This is necessary to account for the large variation in water demands by industry type. See also total industrial activity. Context: Scenario Factor.

infiltration – The flow of water downward from the land surface into and through the upper soil layers.

infiltration capacity – The maximum rate at which infiltration can occur under specific conditions of soil moisture.

infrastructure – the underlying foundation or basic framework of a system

integrated regional water management – A comprehensive, systems approach for determining the appropriate mix of demand and supply management options that provide long-term, reliable water supply at lowest reasonable cost and with highest possible benefits to customers, economic development, environmental quality, and other social objectives.

intercropping – The simultaneous planting of two or more crops in the same field. The practice is used to help control pest populations that can occur on monoculture crops, sometimes called "polycropping" or "plant stratification."

interregional import projects – Movement of water between regions through mechanisms such as the State and federal water projects. Context: Scenario Factor.

irrecoverable water – the amount of applied water that is not available for supply or reuse, including discharge to saline sinks, evaporation, and evapotranspiration. See recoverable water

irrigation efficiency (IE) – The efficiency of water application and use, calculated by dividing a portion of applied water that is beneficially used by the total applied water, expressed as a percentage The two main beneficial uses are crop water use (evapotranspiration, ETc) and leaching to maintain a salt balance.

irrigation water requirements – The quantity of water exclusive of precipitation that is required from various uses.

J

joint powers agreement (JPA) – An agreement entered into by two or more public agencies that allows them to jointly exercise any power common to the contracting parties. The JPA is defined in Ch. 5 (commencing with Section 6500) of Division 7 of Title 1 of the California Government Code.

L

land subsidence – The lowering of the natural land surface due to groundwater (or oil and gas) extraction.

leaching requirements – The fraction of water entering the soil that must pass through the root zone in order to prevent soil salinity from exceeding a specific value.

leaching efficiency – The ratio of the average salt concentration in drainage water to an average salt concentration in the soil water of the root zone when near field capacity.

leaky confining layer – A low-permeability layer that can transmit water at sufficient rates to furnish some recharge from an adjacent aquifer to a well.

lithologic log – A record of the lithology of the soils, sediments and/or rock encountered in a borehole from the surface to the bottom.

lithology – The description of rocks, especially in hand specimen and in outcrop, on the basis of such characteristics as color, mineralogic composition, and grain size.

M

management objectives – Objectives that set forth the priorities and measurable criteria of water management. Examples include improve water quality, augment water supplies, improve use efficiency, etc.

matching water quality to use – a resource management strategy that recognizes not all water uses require the same quality water. High quality water sources can be used for drinking and industrial purposes that benefit from higher quality water, and lesser quality water can be desirable for some uses, such as riparian streams with plant materials benefiting fish. Context: Resource Management Strategy.

maximum contaminant level (MCL) – The highest drinking water contaminant concentration allowed under federal and State Safe Drinking Water Act regulations.

microirrigation – The frequent application of small quantities of water as drops, tiny streams, or miniature spray through emitters or applicators placed along a water delivery line. Microirrigation encompasses a number of methods or concepts such as bubbler, drip, trickle, mist, or spray.

multicropping – The practice of consecutively producing two crops (double cropping) or more of either like or unlike com modities on the same land within the same year. An example of double cropping might be to harvest a wheat crop by early summer and then plant corn or beans on that acreage for harvest in the fall. Suitable climates and reliable water supplies are important factors with this practice.

N

naturally occurring conservation – The amount of background conservation occurring independent of the BMP and EWMP programs (e.g., plumbing codes, etc.). Context: Scenario Factor.

natural recharge – Natural replenishment of an aquifer generally from snowmelt and runoff; through seepage from the surface.

net groundwater withdrawal - groundwater extraction in excess of percolation into a groundwater basin. Context: Water Portfolio net water use (demand) – the amount of water needed in a water service area to meet all requirements or demands. It is the sum of several components including evapotranspiration of applied water in an area, the irrecoverable water from the distribution system, and the outflow leaving the service area; does not include reuse of water within a service area.

new water – Water that is legally and empirically available for a beneficial use; can be developed through many strategies such as capturing surplus water, desalination of ocean water and reductions in depletions. (Same meaning as real water) Context: Planning Concept/Consideration.

nonpoint source – Pollution discharged over a wide land area, not from one specific location. These are forms of diffuse pollution caused by sediment, nutrients, etc., carried to lakes and streams by surface runoff. See also point source

O

operational flexibility – The temporal or spatial operational efficiency of existing and proposed infrastructure to maximize benefits. Context: Evaluation Criteria.

operational yield – An optimal amount of groundwater that should be withdrawn from an aquifer system or a groundwater basin each year. It is a dynamic quantity that must be determined from a set of alternative groundwater management decisions subject to goals, objectives, and constraints of the management plan.

ordinance – A law set forth by a governmental authority.

other interregional import deliveries – This factor is intended to capture the interregional movement of water for "projects" such as Russian River, Trinity River Exports or Putah South Canal. Note that the project name must be specified in the study plan narrative. Context: Scenario Factor.

overdraft – See groundwater overdraft

overlying right – Property owners above a common aquifer possess a mutual right to the reasonable and beneficial use of a groundwater resource on land overlying the aquifer from which the water is taken. Overlying rights are correlative (related to each other) and overlying users of a common water source must share the resource on a pro rata basis in times of shortage. A proper overlying use takes precedence over all non-overlying uses.

P

pelagic fish – fish that spawn in open water, often near the surface. Many river-dwelling anadromous fishes, such as shad are also pelagic spawners

perched groundwater – Groundwater supported by a zone of material of low permeability located above an underlying main body of groundwater.

percolation – Process in which water moves through a porous material, usually surface water migrating through soil toward a groundwater aquifer.

perennial yield – The maximum quantity of water that can be annually withdrawn from a groundwater basin over a long period of time (during which water supply conditions approximate average conditions) without developing an overdraft condition.

permeability – The capability of soil or other geologic formations to transmit water.

pesticide – Any of a class of chemicals used for killing insects, weeds, or other undesirable entities. Most commonly associated with agricultural activities, but has significant domestic use in California.

point source – A specific site from which wastewater or polluted water is discharged into a water body. See also nonpoint source

pollution (of water) – The alteration of the physical, chemical, or biological properties of water by the introduction of any substance into water that adversely affects any beneficial use of water.

pollution prevention – Improving water quality for all beneficial uses by protecting water at its source, reducing the need and cost for other water management actions and treatment. Context: Resource Management Strategy.

population density – The average number of people per square mile for a planning area. Context: Scenario Factor.

population distribution – The geographic location within California of the population projection. Context: Scenario Factor.

population projection – The 2030 forecast of population made by the California Department of Finance or other agencies. Context: Scenario Factor.

porosity – The ratio of the voids or open spaces in alluvium and rocks to the total volume of the alluvium or rock mass.

possible contaminating activity (PCA) – Human activities that are actual or potential origins of contamination for a drinking water source. PCAs include sources of both microbiological and chemical contaminants that could have an adverse effect upon human health.

precipitation enhancement – The action of artificially stimulating clouds "cloud seeding" to produce more rainfall/snowfall than would naturally occur. Context: Resource Management Strategy.

prescriptive right – Rights obtained through the open and notorious adverse use of another's water rights. By definition, adverse use is not use of a surplus, but the use of non surplus water to the direct detriment of the original rights holder.

public trust doctrine–A legal doctrine recognizing public rights in the beds, banks, and waters of navigable waterways, and the State's power and duty to exercise continued supervision over them as trustee for the benefit of the people.

public water system – A system for the provision of water for human consumption through pipes or other constructed conveyances that has 15 or more service connections or regularly serves at least 25 individuals daily at least 60 days out of the year.

pueblo right – A water right possessed by a municipality which, as a successor of a Spanish or Mexican pueblo, entitled to the beneficial use of all needed, naturally occurring surface and groundwater of the original pueblo watershed Pueblo rights are paramount to all other claims.

R

rate structure – Designates the rate basis for cost recovery (e.g., flat, uniform, tiered, etc.). Block/Tiered rates are assumed to provide cost signals to consumers. Costs can include capital, O&M, financing, environmental compliance (documentation, permitting and mitigation), etc. Context: Scenario Factor.

real water – See new water. Context: Planning Concept/Consideration.

recharge – Water added to an aquifer or the process of adding water to an aquifer. Groundwater recharge occurs either naturally as the net gain from precipitation or artificially as the result of human influence. See also artificial recharge.

recharge area protection – The action of keeping recharge areas from being paved over or otherwise developed and guarding the recharge areas so they don't become contaminated Context: Resource Management Strategy.

recharge basin – A surface facility constructed to infiltrate surface water into a groundwater basin.

recoverable water – the amount of applied water that is available for supply or reuse; including surface runoff to non-saline bodies of water and deep percolation that becomes groundwater.
See irrecoverable water

recreation – Water-dependent recreation activities that are consumptive (e.g., parks), flat-water (e.g., boating), or flow-based (e.g., whitewater rafting). Context: Scenario Factor.

recreation (reservoir-based) – Flat water recreation, such as boating and skiing, in the form of future storage facilities as well as operation of existing surfaces storage facilities. Context:

recreation sport-fish populations – Populations of fish species that support recreational fishing.

recreation (watercourse-based) – Activities that are dependent on instream flows such as whitewater rafting. Context:

recycled water – Treated municipal, industrial, or agricultural wastewater to produce water that can be reused. Context: Resource Management Strategy

regional self-sufficiency – The degree to which a study plan involves implementation of regional water management options. Context: Evaluation Criteria.

reliability planning – Water reliability management planning is done by comparing the costs of taking actions to maintain or increase reliability to the costs of accepting less reliability. On this basis, accepting of the costs of adverse effects of less than 100 percent reliability could be a legitimate planning decision. Providing full water supply to meet 100 percent of projected future water demand is not the planning goal, rather, the goal is to find the justified level of reliability. Context: Planning Concept/Consideration.

resource management strategy – A project, program, or policy that helps federal, State or local agencies manage water and related resources. Resource Management Strategies can reduce water demand, improve operational flexibility, increase water supply, improve water quality, or practice resource stewardship.

response packages – Additional sets of resource management strategies to be tested against future scenario conditions for performance comparison. This analysis will take place in California Water Plan Update 2010. Comparing the performance of different response packages will provide useful information to decision-makers and water managers as they choose actions to achieve a desirable future water condition.

return-flow system – A system of pipelines or ditches to collect and convey surface or subsurface runoff from an irrigated field for reuse.

reused agricultural water – Water that is used by more than one grower and is, therefore, not available for reallocation should one grower become increasingly efficient (i.e., applied water reductions minus real water equal zero). Context: Planning Concept/Consideration.

riparian right – A right to use surface water, such right derived from the fact that the land in question abuts the banks of streams.

root zone – The portion of the soil profile through which plant roots readily penetrate to obtain water and plant nutrients, expressed in inches or feet of depth.

runoff – The volume of surface flow from an area.

S

safe yield – The maximum quantity of water that can be continuously withdrawn from a groundwater basin without adverse effect

saline soil – A nonalkali soil containing soluble salts in such quantities that they interfere with the growth of most plants.

saline intrusion – The movement of salt water into a body of fresh water. It can occur in either surface water or groundwater bodies.

salinity – Generally, the concentration of mineral salts dissolved in water. Salinity may be expressed in terms of a concentration or as electrical conductivity. When describing salinity influenced by seawater, salinity often refers to the concentration of chlorides in the water.

saturated zone – The zone in which all interconnected openings are filled with water, usually underlying the unsaturated zone.

scenarios – Sets of plausible future conditions based on different assumptions of factors such as population size, density, and distribution, per capita income, commercial and industrial activity, and crop area and water use. In California Water Plan Update 2005, the three scenarios for 2030 are strictly narrative and are "no action" (i.e., they do not reflect any additional resource management strategies in the form of response packages beyond those currently planned, such as new water efficiency programs).

seasonal vs. permanent crop mix – Shifts in crop type between seasonal and permanent. This factor depicts the diminished ability to reduce water use during times of increased water scarcity (due to shifting from seasonal to permanent crops). In other words, shortage losses increase when shifting from season to permanent. Context: Scenario Factor.

seawater intrusion barrier – A system designed to retard, cease or repel the advancement of seawater intrusion into potable groundwater supplies along coastal portions of California. The system may be a series of specifically placed injection wells where water is injected to form a hydraulic barrier.

secondary porosity – Voids in a rock formed after the rock has been deposited; not formed with the genesis of the rock, but later due to other processes. Fractures in granite and caverns in limestone are examples of secondary openings.

seepage – The gradual movement of water into, through, or from a porous medium. Also, the infiltration of water into the soil from canals, ditches, laterals, watercourse, reservoir, storage facilities, or other body of water, or from a field.

semi-confined aquifer – A semi-confined aquifer or leaky confined aquifer is an aquifer that has aquitards either above or below that allow water to leak into or out of the aquifer depending on the direction of the hydraulic gradient.

service area – The geographic area served by a water agency.

soil moisture – The water in soils. Usually expressed as a percentage of the dry weight of the soil. Can also be expressed on a wet weight or a volume basis.

soil texture – Soil texture refers to the percentage of sand, silt, and clay particles in a soil. Sand, silt, and clay particles are defined by their size. Soil texture has important effects on soil properties. Water-holding capacity, drainage class, consistence, and chemical properties are just a few examples of properties that are affected by soil texture.

specific retention – The ratio of the volume of water a rock or sediment will retain against the pull of gravity to the total volume of the rock or sediment.

specific yield – the ratio of the volume of water a rock or soil will yield by gravity drainage to the total volume of the rock or soil.

spring – a location where groundwater flows naturally to the land surface or a surface water body.

sprinkler irrigation – Method of irrigation in which the water is sprayed, or sprinkled, through the air to the ground surface.

stakeholder – individuals or groups who can affect or be affected by an organization's activities. or: Individuals or groups with an interest or "stake" in what happens as a result of any decision or action. Stakeholders do not necessarily use the products or receive the services of a program.

State Water Project deliveries – The volume of water imported to a given study area from the State Water Project. Context: Scenario Factor.

statewide water management systems – These include physical facilities (more than 1,200 State, federal, and local reservoirs, as well as canals, treatment plants, and levees), which make up the backbone of water management in California, and statewide water management programs, which include water-quality standards, monitoring programs, economic incentives, water pricing policies, and statewide water-efficiency programs such as appliance standards, labeling, and education.

strategic plan – The long-term goals of an organization or program and an outline of how they will be achieved (e.g., adopting specific strategies, approaches, and methodologies).

stratigraphy – The science of rocks. It is concerned with the original succession and age relations of rock strata and their form, distribution, lithologic composition, fossil content, geophysical and geochemical properties—all characters and attributes of rocks as strata—and their interpretation in terms of environment and mode of origin and geologic history.

stress irrigation – Management of irrigation water to apply less than enough water to satisfy the soil water deficiency in the entire root zone. (Preferred term is limited irrigation.)

subirrigation – Application of irrigation water below the ground surface by raising the water table to within or near the root zone.

subsurface drip irrigation – Application of water below the soil surface through emitters, with discharge rates generally in the same range as drip irrigation. This method of water application is different from and not to be confused with subirrigation where the root zone is irrigated by water table control.

surface irrigation – Irrigation in which the soil surface is used as the conduit, as in furrow and border irrigation, and as opposed to sprinkler, drip, and subirrigation.

surface storage facilities – The volume and yield of usable reservoir storage in a given area. Context: Resource Management Strategy.

surge irrigation – A surface irrigation technique wherein flow is applied to furrows (or less commonly, borders) intermittently during a single irrigation set.

subsidence – See land subsidence

subterranean stream – Subterranean streams "flowing through known and definite channels" are regulated by California's surface water rights system.

surface supply – Water supply obtained from streams, lakes, and reservoirs.

surplus water – Water that is not being used directly or indirectly to benefit the environmental, agricultural or urban use sectors. Context: Planning Concept/Consideration.

sustainability – A specific resource that avoids complete depletion over a specified time horizon. The continued feasibility of a specified economic activity over a specified time horizon, usually influenced by management and policy actions t Context: Economic Activity.

system reoperation – Changing existing water system operation and management procedures or priorities to either meet competing beneficial uses or derive more total benefits from the water system by operating more efficiently. Context: Resource Management Strategy.

T

third party impacts – The occurrence of incidental economic impacts to parties not directly related to (impact-causing) water management actions. For example, agricultural land retirement can impact local tax revenues and/or labor conditions, etc. Context: Evaluation Criteria.

total capital cost – Total monetary cost of option required for "turn key" implementation including environmental and third party impact mitigation, storage, conveyance, energy, capitalized O&M, administrative, planning, legal and engineering costs. Context: Planning Concept/Consideration.

total commercial activity – The amount of commercial activity (e.g., employment, productivity, commercial land use, etc) that occurs in a given study area. This factor is a driver of (and indicator for) commercial water use and includes institutional water use (government offices, schools, etc.) as well. See also commercial activity mix. Context: Scenario Factor.

total industrial activity – The total amount of industrial activity (e.g., employment, productivity, industrial land use, etc) that occurs in a given study area. This factor is a driver of (and indicator for) industrial water use. Context: Scenario Factor.

total irrigated crop area – The total area of irrigated crops (by type) planted in a planning area during a given year. This number includes multiple cropping. Context: Scenario Factor.

total population – The statewide total population projection regardless of geographical distribution. Context: Scenario Factor.

transpiration – An essential physiological process in which plant tissues give off water vapor to the atmosphere.

U

unconfined aquifer – An aquifer which is not bounded on top by an aquitard. The upper surface of an unconfined aquifer is the water table.

underground stream – Body of water flowing as a definite current in a distinct channel below the surface of the ground, usually in an area characterized by joints or fissures. Application of the term to ordinary aquifers is incorrect.

unit applied water – The quantity of water applied to a specific crop per unit area (sometimes expressed in inches of depth).

unsaturated zone – The zone below the land surface in which pore space contains both water and air.

urban land use management – Planning for the housing and economic development needs of the growing population while providing for the efficient use of water and other resources.

urban runoff management – A broad series of activities to manage both storm water and dry weather runoff.

Urban Water Management Planning Act – Sections 10610 through 10657 of the California Water Code. The Act requires urban water suppliers to prepare urban water management plans which describe and evaluate sources of water supplies, efficient uses of water, demand management measures, implementation strategies and schedules, and other relevant information and programs within their water service areas. Urban water suppliers (CWC Section 10617) are either publicly or privately owned and provide water for municipal purposes, either directly or indirectly, to more than 3,000 customers or supply more than 3,000 acre-feet of water annually.

[urban] water reliability (average) – A measure of a system's ability to sustain the social, environmental and economic systems that it serves during a year of average participation. Context: Evaluation Criteria.

[urban] water reliability (dry) – A measure of a system's ability to sustain the social, environmental and economic systems that it serves during a dry year. Context: Evaluation Criteria.

[urban] water reliability (wet) – A measure of a system's ability to sustain the social, environmental and economic systems that it serves during a wet year. Context: Evaluation Criteria.

urban water use efficiency – Methods or technologies resulting in the same beneficial residential, commercial, industrial, and institutional uses with less water or increased beneficial uses from existing water quantities. Context: Scenario Factor, Resource Management Strategy.

usable storage capacity – The quantity of groundwater of acceptable quality that can be economically withdrawn from storage.

V

volatile organic compound (VOC) – A manmade organic compound that readily vaporizes in the atmosphere. These com pounds are often highly mobile in the groundwater system and are generally associated with industrial activities.

W

water bag transport/storage technology – Water diverted in areas that have unallocated fresh water supplies, storing the water in large inflatable bladders, and towing to an alternate coastal region. Context: Resource Management Strategy.

water balance – An analysis of the total developed/dedicated supplies, uses, and operational characteristics for a region.

water demand – The desired quantity of water that would be used if the water is available and a number of other factors such as price do not change. Demand is not static.

water demand elasticity – The desire to use water is based on a number of factors such as the intended use for the water, the price of water, and the cost of alternative ways to meet the intended use.

water portfolio – A picture of the water supply and use for a given year statewide or by region, subject to availability of data; includes the flow diagram, flow diagram table, water balances, and summary table.

water quality – Description of the chemical, physical, and biological characteristics of water, usually in regard to its suitability for a particular purpose or use.

water reliability (dry) – A measure of a system's ability to sustain the social, environmental, and economic systems that it serves during a dry year.

water reliability (wet) – A measure of a system's ability to sustain the social, environmental, and economic systems which it serves during a wet year.

water supply exports – The amount of water that a region transfers to another to meet needs. Context: Regional Reports.

water supply imports – The amount of water that needs to be brought in from other regions to meet needs. Context: Regional Reports.

water table – See groundwater table

water transfers – A temporary or long-term change in the point of diversion, place of use, or purpose of use due to a transfer or exchange of water or water rights. A more general definition is that water transfers are a voluntary change in the way water is usually distributed among water users in response to water scarcity. Context: Scenario Factor, Resource Management Strategy.

water year – A continuous 12-month period for which hydrologic records are compiled and summarized. Different agencies may use different calendar periods for their water years.

watershed – The land area from which water drains into a stream, river, or reservoir.

watershed management – The process of evaluating, planning, managing, restoring, and organizing land and other resource use within an area that has a single common drainage point. Context: Resource Management strategy.

Metric Conversion Factors				
Quantity	**To Convert from Metric Unit**	**To Customary Unit**	**Multiply Metric Unit By**	**To Convert to Metric Unit Multiply Customary Unit By**
Length	millimeters (mm)	inches (in)	0.03937	25.4
	centimeters (cm) for snow depth	inches (in)	0.3937	2.54
	meters (m)	feet (ft)	3.2808	0.3048
	kilometers (km)	miles (mi)	0.62139	1.6093
Area	square millimeters (mm^2)	square inches (in^2)	0.00155	645.16
	square meters (m^2)	square feet (ft^2)	10.764	0.092903
	hectares (ha)	acres (ac)	2.4710	0.40469
	square kilometers (km^2)	square miles (mi^2)	0.3861	2.590
Volume	liters (L)	gallons (gal)	0.26417	3.7854
	megaliters (ML)	million gallons (10*)	0.26417	3.7854
	cubic meters (m^3)	cubic feet (ft^3)	35.315	0.028317
	cubic meters (m^3)	cubic yards (yd^3)	1.308	0.76455
	cubic dekameters (dam^3)	acre-feet (ac-ft)	0.8107	1.2335
Flow	cubic meters per second (m^3/s)	cubic feet per second (ft^3/s)	35.315	0.028317
	liters per minute (L/mn)	gallons per minute (gal/mn)	0.26417	3.7854
	liters per day (L/day)	gallons per day (gal/day)	0.26417	3.7854
	megaliters per day (ML/day)	million gallons per day (mgd)	0.26417	3.7854
	cubic dekameters per day (dam^3/day)	acre-feet per day (ac-ft/day)	0.8107	1.2335
Mass	kilograms (kg)	pounds (lbs)	2.2046	0.45359
	megagrams (Mg)	tons (short, 2,000 lb.)	1.1023	0.90718
Velocity	meters per second (m/s)	feet per second (ft/s)	3.2808	0.3048
Power	kilowatts (kW)	horsepower (hp)	1.3405	0.746
Pressure	kilopascals (kPa)	pounds per square inch (psi)	0.14505	6.8948
	kilopascals (kPa)	feet head of water	0.32456	2.989
Specific capacity	liters per minute per meter drawdown	gallons per minute per foot drawdown	0.08052	12.419
Concentration	milligrams per liter (mg/L)	parts per million (ppm)	1.0	1.0
Electrical conductivity	microsiemens per centimeter (μS/cm)	micromhos per centimeter (μmhos/cm)	1.0	1.0
Temperature	degrees Celsius (°C)	degrees Fahrenheit (°F)	(1.8X°C)+32	0.56(°F-32)

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